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Advanced Manufacturing

SPECIAL ISSUE

Manufacturing Innovation and Technological Superiority

by the Under Secretary of Defense for Acquisition, Technology, and Logistics

Learning from the Past to Plan for the Future

Restoring Manufacturing for National Security

Keeping Track of Horseshoe Nails

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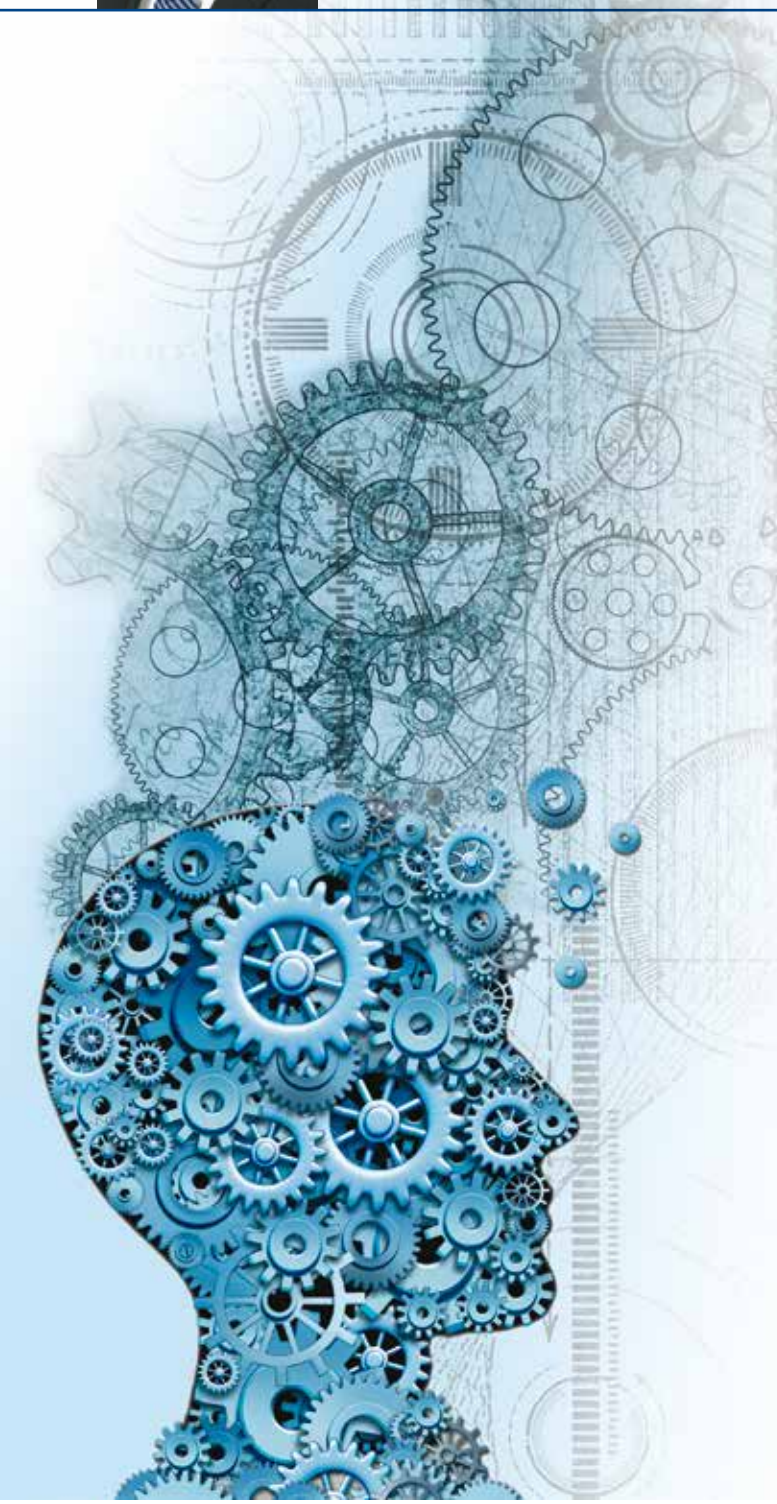
Manufacturing Innovation and Technological Superiority

Frank Kendall



At the end of the Cold War, I was serving as the Deputy Director of Defense Research and Engineering for Tactical Warfare Programs in the Office of the Secretary of Defense (OSD). For years I had studied the intelligence reports on Soviet weapon systems and worked on ways the United States could achieve or maintain a military advantage over those systems. We knew the Russians had some of the best scientists and engineers in the world working on their designs. They also had aggressive modernization cycles in areas they considered important; their multiple competing design bureaus turned out new designs for armored vehicles, missiles and tactical aircraft on a predictable schedule at intervals of about 5 years.

After the Cold War ended, I was anxious to get a close look at the Soviet weapons systems we had been working to defeat. I soon had two opportunities to examine the newest Soviet equipment up close. One was a display at Andrews Air Force Base in Maryland of all the equipment that we acquired to test once the wall came down and the Russians were desperate for any source of cash. The other was at the Farnborough International Airshow in England, where the Russians were offering to sell their most modern systems to anyone who would buy them. What struck me most when I examined the former Soviet equipment was how primitive their production technology was compared to U.S. manufacturing technology.

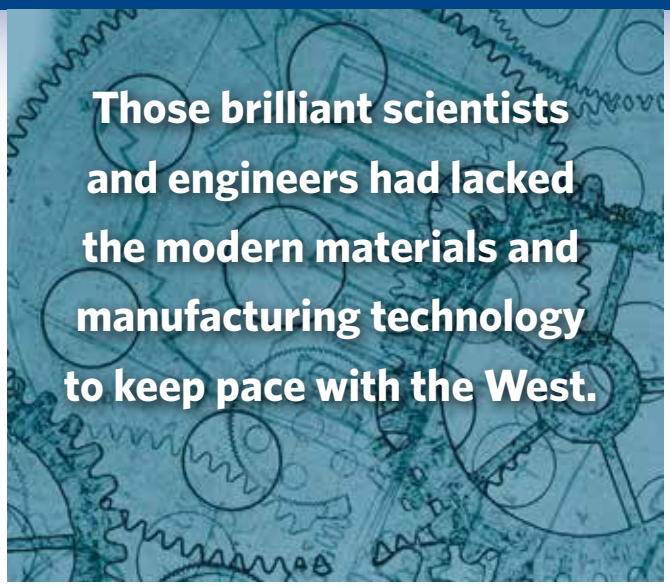
Those brilliant scientists and engineers had lacked the modern materials and manufacturing technology to keep pace with the West. It was clear that the performance and reliability of their

weapons systems had been severely limited by their limitations in areas like precision machining; the ability to fabricate multilayer printed circuit boards; and their inability to produce integrated circuits.

I recall in particular the presence of Bakelite, a distinct early plastic thermosetting insulating material, which the United States hadn't used since the 1950s, being everywhere in Soviet 1980s-era aircraft. One of the greatest constraints on the Soviet designers, and on the performance and cost of their weapons systems had been manufacturing technology.

Manufacturing technology doesn't just affect weapons systems and technological superiority—it also drives national economic performance. The first and second industrial revolutions were largely about manufacturing technology. The English advantages in mechanized textile manufacturing in the early 1800s drove the performance of the British economy, just as Carnegie's steel production in the late 19th century and Ford's mass production technology early in the 20th drove the growth of the U.S. economy. More recently, ever smaller and more efficient silicon-based integrated circuits that can be economically manufactured in massive quantities are driving economic growth around the world.

Recognizing the importance of manufacturing technology to both national security and our economy, the President initiated a program to establish Manufacturing Innovation Institutes (MIIs) that would create incubators for advanced manufacturing technology in key technological areas. The Department of Defense (DoD) has been a national leader in establishing these institutions. With the Acting Secretary of Commerce and the National Economic Advisor, I opened the first one—which is dedicated to advancing additive manufacturing (3D printing) technology—in Youngstown, Ohio, in 2012. Since then, several more MIIs have been opened, two by the Department of Energy and six by the DoD. Several more are on the way. The technologies of interest are determined by an expert interagency body with industry input. Focus areas include lightweight alloys, digitization of design to manufacturing processes and flexible electronics. All of these new institutions depend on collaboration between federal and local government, industry and academia. Government funding is combined with other sources of funds to get these institutions up and running, but they will have to be self-sufficient in a few years when government funding will cease. We don't know if every MII will flourish; we will let time and the requirement to be self-sufficient sort that out. Four years in we do know that some of the MIIs we have established are off to a good start, with continuing interest from industry, significant advances in manufacturing technology and successful products to their credit.



I would like to recognize some key DoD leaders who have organized and led the competitive process to set up the MIIs. First Brett Lambert, then Elana Broitman, and now Andre Gudger, as leaders of the DoD's Manufacturing and Industrial Base Policy organization, have been the senior leaders responsible for the DoD's MIIs. A remarkable team, led by Adele Ratcliff (whose article in this edition of *Defense AT&L* magazine provides much more detail on the MIIs), has done the heavy lifting required to make each of the MIIs a reality. Each of the Military Departments also has played a strong role—conducting the actual competitions and working with the selected consortium to get the MIIs up and running. All of these dedicated professionals deserve our appreciation for creating these new national assets.

While the MIIs are important, they are only one source of the technologies that will make building our future generations of weapons possible and affordable. Industry investments are focused on staying competitive in an ever-more-competitive world, and help to keep the United States competitive against potential adversaries.

I have been encouraging defense companies to invest more in research and development, and one of the areas of greatest promise is on technologies that will lower the production costs and improve the performance of our weapons systems. Industry is responding. One example is the "blueprint for affordability" initiative in which Lockheed Martin and major F-35 suppliers have agreed to undertake to reduce F-35 production costs. Through a creative "win-win" agreement, Lockheed Martin and the major suppliers for the F-35—Northrop Grumman and BAE—are all making investments that will reduce government cost and achieve a higher return for the industry participants. Pratt & Whitney has a similar program for the F-135 engine. In another example, Boeing has invested significantly in its

groundbreaking proprietary manufacturing processes that are expected to pay strong dividends in both military and commercial aircraft manufacturing. Industry understands that manufacturing technology is the key to competitiveness.

For more than 50 years, the DoD Manufacturing Technology Program, or ManTech, has been used by the DoD to sustain our lead in defense-essential manufacturing capability. The ManTech Program, executed through dedicated teams in the Services, agencies, and within the OSD, develops technologies and processes that impact all phases of acquisition and reduce both acquisition and total ownership costs by developing, maturing, and transitioning key manufacturing technologies. ManTech not only provides the crucial link between technology invention and development and industrial applications, but also matures and validates emerging manufacturing technologies to support feasible implementation in industry and DoD facilities like depots and shipyards.

Direct investments by the government have often been the genesis of new manufacturing technology and a catalyst to spur more investment by industry. When I was vice president of engineering at Raytheon in the 1990s, I was able, with the CEO's strong support, to protect our corporate investment in the technology needed to produce gallium arsenide radio frequency components, a key enabler for a range of important national security projects and a major competitive advantage for the company. More recently, government support, together with industry investments, for Gallium Nitride components is giving the United States the opportunity to produce systems like the Next Generation Jammer, the Advanced Missile Defense Radar and others.

For the acquisition professionals managing our new product development programs, manufacturing technology and the risk associated with bringing new technology on line, should be major partsof program planning. Our policy encourages the use of Manufacturing Readiness Levels as one way to assess the maturity and risk associated with producing specific designs. As I hope you know by now, I'm not a fan of readiness levels—they convey no real information about the actual risk or the difficulty of maturing a technology to where it can be used in a product or in manufacturing a product—but they do provide a place to start a conversation about that risk. Managing the risk associated with manufacturing is as important as managing the technological risk associated with performance. This isn't a new problem. When I was working on my MBA in the 1970s, we did a case study on how to manage creative designers who failed to appreciate the difficulty associated with actually producing their ingenious designs. While a new idea might work in theory, if it can't be built at an affordable cost it doesn't have much value. As we build risk reduction plans and proactively manage the risks associated with new capabilities we cannot afford to neglect the importance of having mature manufacturing processes.

Given the importance of manufacturing technology, we must protect that technology just as we protect the actual designs and performance characteristics of our weapon systems. As I work with our international partners, one thing is almost a constant—the desire to acquire advanced manufacturing expertise in order to build more competitive manufacturing capacity and create jobs. Our competitors as well as our friends understand the importance of manufacturing technology, and they have no reticence about using every available means to acquire that technology—especially cyber theft. As we build Program Protection Plans, we must include the steps we will take to protect critical manufacturing technology—throughout the supply chain.

This issue of *Defense AT&L* magazine is focused on manufacturing, the various MIIs and on our programs, such as ManTech, established to invest in critical manufacturing technology. As we plan and execute our research efforts and our development programs, we all should be conscious of the importance of advancing the state of the art in manufacturing, of managing the risks associated with manufacturing, and of protecting the manufacturing technologies that we need to maintain our technological superiority over our most capable potential opponents. You can be certain that potential adversaries are working very hard to avoid the disadvantage embedded in the Soviet weapon systems I was so anxious to investigate at the end of the Cold War.

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Learning From the Past to Plan for the Future

Restoring Manufacturing for National Security

A. Adele Ratcliff

President Roosevelt on the eve of World War II reached out to industry and sought its advice on how to meet pending war production demands. The current administration has sought industry's advice on how to restore our competitive advantage—in peacetime and war—through public-private cooperative partnerships. The aim is to develop "ecosystems" that promote emerging technologies and deliver new capabilities to the warfighter. Based on the advice received, the Department of Defense (DoD) established the first of eight Manufacturing Innovation Institutes, or MIIs, in 2012.

Manufacturing dominance underpins technical dominance. Historically, the colocation of scientific invention with strong manufacturing and workforce competencies has allowed the United States to move promising technologies

Ratcliff *has been director of the Department of Defense (DoD) Manufacturing Technology Program, since 2004. She has spearheaded establishment of the six DoD Manufacturing Innovation Institutes already set up and has launched the two currently under development.* *The author wishes to thank Leo Grassilli for turning her on to the book "Freedom's Forge" by Arthur Herman, which captured and preserved the history of the heroic efforts of the U.S. defense industrial base during World War II. Herman has been a close advisor to the author on matters related to the U.S. industrial base.*

into mass production, catapulting America into its position as the world's leader for innovation. It also has given our nation a decided strategic advantage to prepare for and deter wars and, when necessary, to prosecute and win them.

Last year during the 70th anniversary of the end of World War II, we celebrated the Arsenal of Democracy with a flyover of more than 70 military aircraft from that era. It was testimony to both the fighting tenacity of the women and men of that generation and the contributions of an invigorated defense industrial base to our national security.

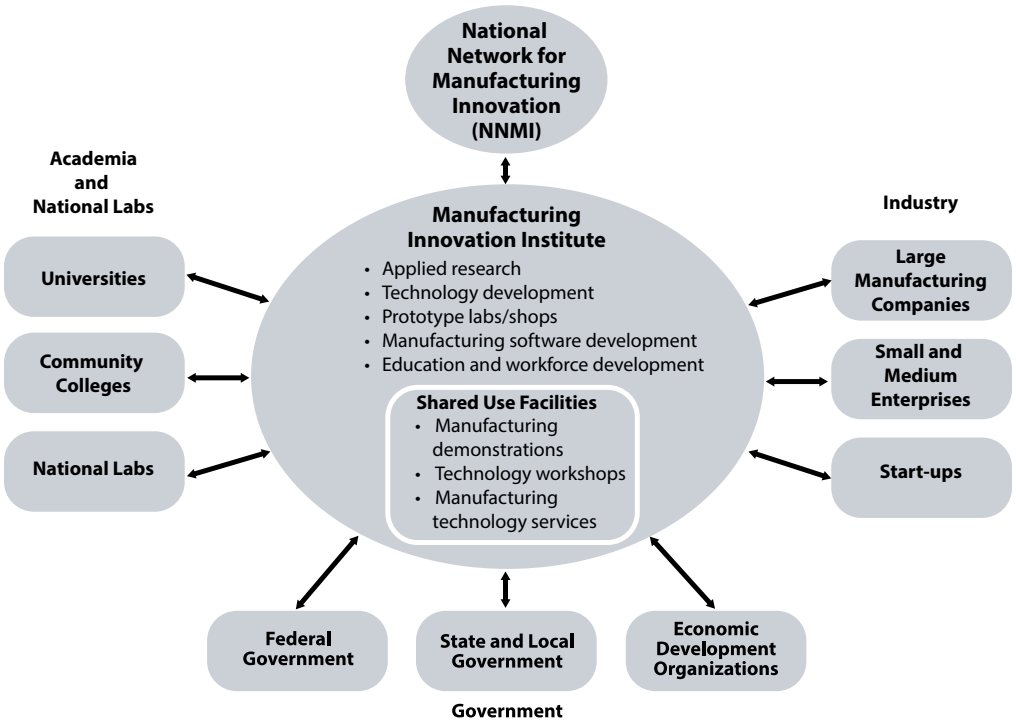
In retrospect, it wasn't easy getting there. In 1939, when Gen. George S. Patton took command of the 2nd Armored Brigade in Fort Benning, Georgia, he had a meager 325 World War I vintage tanks. At that time, the German army possessed nearly 2,000 modern Panzers. In fact, Patton had to use his own money to purchase nuts and bolts from Sears and Roebuck to equip the U.S. Army. The military aircraft situation was no better. Our defense industrial base could muster a mere 70 airplanes per month. Defense factories eventually would expand, producing thousands of airplanes every month to meet U.S. and Allied requirements.

Competition has been shown to be useful up to a certain point and no further, but cooperation, which is the thing we must strive for today, begins where competition leaves off.

—Franklin D. Roosevelt

In 2016, America is not in the same dismal war-readiness shape as it was on the eve of World War II. Nevertheless, the manufacturing base faces significant pressure as it works to support a new generation of technologically advanced war-fighting capabilities. In recent years, the Great Recession, the wars in Iraq and Afghanistan, and ongoing cutbacks in defense spending have distracted us from structural weaknesses in our defense manufacturing base. Fortunately, a countermovement is growing in government and industry to address these weaknesses and restore the critical linkage between manufacturing and defense. The building blocks for renewal are coming into place.

Figure 1. Interconnections in the Network



Today there is strategic promise for the DoD in new emerging technologies such as revolutionary fibers and textiles, integrated photonics, flexible hybrid electronics, and regenerative tissue. As technology becomes more complex, so have the corresponding manufacturing technologies and processes needed to convert research into products. In many cases, the developing manufacturing technologies are more challenging than the initial technology itself. While competition can drive innovation and reduce costs in mature technology areas, there is a need for cooperation to build manufacturing capabilities where complexity is beyond the ability of or risk taken by any single company to address and gaps are left in emerging areas.

The MIIs are a new frontier for manufacturing—public-private partnerships establishing rich healthy ecosystems focused on manufacturing shortfalls of new promising technologies. Along with Departments of Commerce (DoC) and Energy (DoE), the DoD-led MII program is a major component of the government-wide National Network for Manufacturing Innovation (NNMI). (See the *National Network for Manufacturing Innovation Program—Annual Report*, February 2016 [http://www.manufacturing.gov/files/2016/02/2015-NNMI-Annual-Report.pdf]).

How an MII Works and Operates

The NNMI and agency-led MIIs are industry-driven public-private partnerships focused on advancing manufacturing for specific technology sectors. Within this broad rubric, the DoD-sponsored MIIs focus on advancing manufacturing technologies and applications for both commercial and defense needs. Each MII creates the critical infrastructure necessary to provide a dynamic, highly collaborative environment spurring manufacturing technology innovations and technology transfer, leading to domestic production scale-up and commercialization. MIIs also provide the DoD with access to key enabling technologies that cost-effectively enhance the performance and capabilities of future defense systems. The DoD MIIs all share the following characteristics:

- They are regional hubs of manufacturing excellence with a national impact. They bring together industry, universities, community colleges, federal agencies and states to share infrastructure assets and knowledge to help U.S. companies gain access to cutting-edge advanced manufacturing capabilities and equipment.
- They are led by a nonprofit organization with the capacity to lead an industry-wide manufacturing technology, workforce development, and infrastructure agenda.
- They invest in applied research in industrially relevant manufacturing technologies with broad applications that accelerate innovation and bridge the gap between basic research and product development (in the Technology Readiness Level or Manufacturing Readiness Level 4-7 range).
- They educate and train students and workers in advanced manufacturing skills.
- They require a minimum of 1:1 nonfederal co-investment.
- They become self-sustaining after 5 years of core institute funding.

The Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy is responsible for managing the DoD MII program. Since 2012, six DoD institutes have been established, and two more are in competition:

2012—America Makes. Headquartered in Youngstown, Ohio, America Makes focuses on a wide spectrum of additive manufacturing technologies.

2014—Digital Manufacturing and Design Innovation. Headquartered in Chicago, this institution seeks to improve the utilization of data across the entire manufacturing process and product life cycle. Design, production and assembly operations and the entire supply chain are optimized to reduce the cost and time involved in manufacturing.

2014—Lightweight and Modern Metals Manufacturing Innovation (now referred to as LIFT: Lightweight Innovations for Tomorrow). Headquartered in Detroit, LIFT focuses on accelerating the transfer of new lightweight metals and manufacturing technologies from the lab to the production floor.

2015—American Institute for Manufacturing (AIM) Integrated Photonics-AIM Photonics. Headquartered in Albany, New York, AIM focuses on developing an end-to-end integrated photonics ecosystem in the United States, including domestic foundry access, integrated design tools, automated packaging, assembly and test, and workforce development.

2015—NextFlex. Headquartered in San Jose, California, NextFlex is developing flexible hybrid electronics to support wearable electronics and new medical and sensor capabilities.

2015—Advanced Functional Fabrics of America (AFFOA). Headquartered in Boston, AFFOA will deliver revolutionary advances across the entire fabric supply chain enabling fiber to act as an electronic device. In addition, new multifunctional fibers and advanced nonwovens and yarn production will provide lightweight structural and protective capabilities.

Two additional DoD-led institutes are in competition:

2016—Advanced Tissue Biofabrication (ATB) Institute. This new center will bring together the diverse collection of industry practices across many disciplines (cell biology, bioengineering, materials science, analytical chemistry, robotics and quality assurance) to realize the promises of advanced tissue biofabrication.

2016-2017—Robots in the Manufacturing Environment. This new center is focused on machine-to-machine collaboration at the shop floor and human-to-machine interface. The same technology can be applied in commercial robots in medical procedures, space exploration, mines and earthmoving, and service robots at home and in patient recuperation—especially for the aging population.

Today there is strategic promise for the DoD in new emerging technologies such as revolutionary fibers and textiles, integrated photonics, flexible hybrid electronics, and regenerative tissue.

In addition to those of the DoD, the DoE has established two MIIs with three in planning and acquisition.

DoE—2014 Power America. Headquartered in Raleigh, North Carolina, Power America focuses on wide-bandgap semiconductor technologies for next-generation, energy-efficient high-power electronic components and assemblies that are cost competitive with current silicon-based power electronics.

DoE—2015 Institute for Advanced Composites Manufacturing Innovation. Headquartered in Knoxville, Tennessee, the Institute focuses on fiber-reinforced polymer composites targeting clean energy manufacturing industries. There is a particular emphasis on wind, automotive and compressed gas storage tanks applications.

DoC/NIST currently is establishing two additional institutes this year. This will bring the total to 15 institutes established since 2012. The DoD has been operating at breakneck pace since 2012 to establish the MIIs. Early indications suggest that we have made the right call. We are taking the long view toward defense-related manufacturing and its role in innovation, technical dominance and the preservation of our strategic warfighting advantage. Our defense readiness and national security needs demand nothing less.

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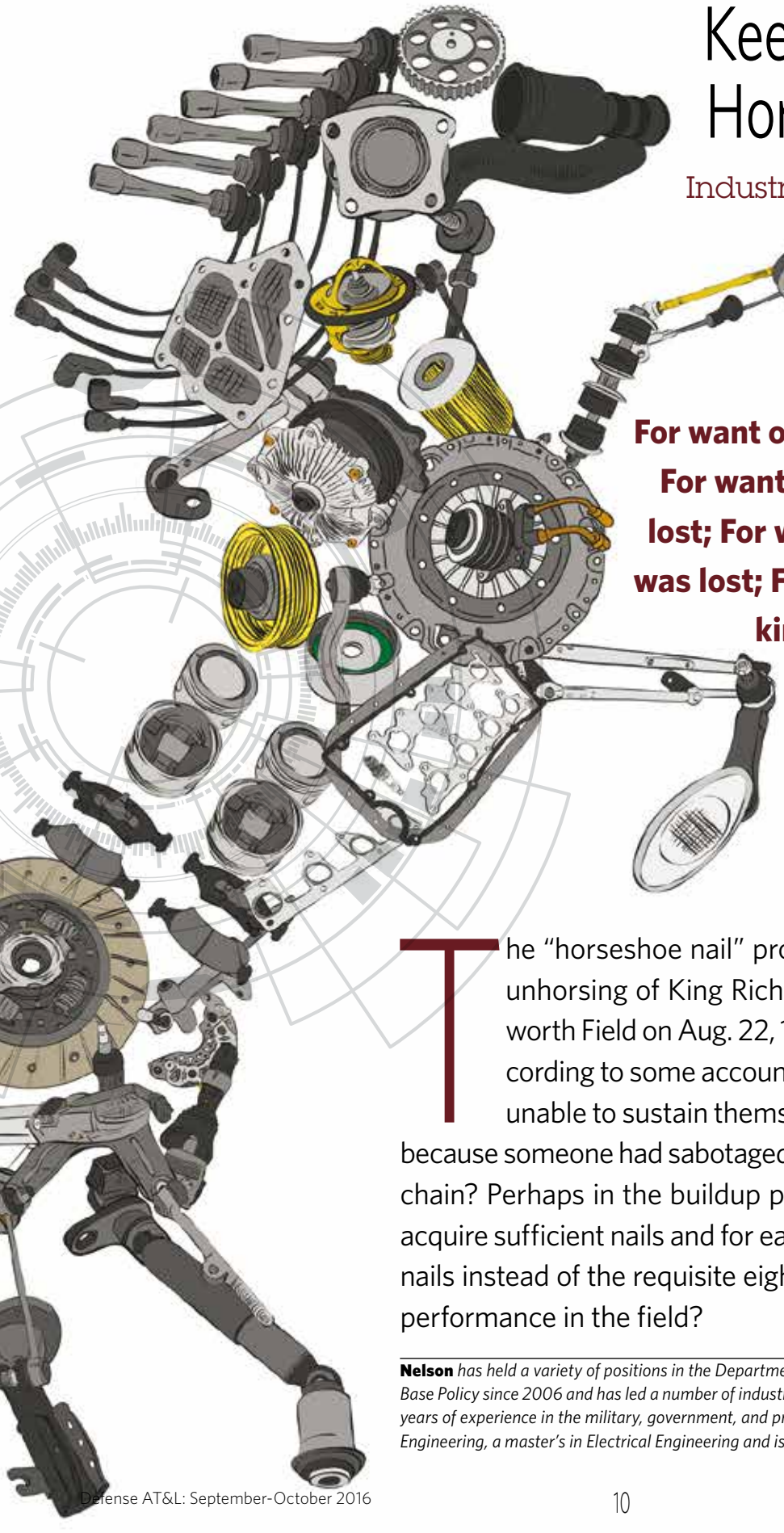

Keeping Track of Horseshoe Nails

Industrial Base Analysis and Sustainment

Bradley K. Nelson

For want of a nail, the shoe was lost; For want of a shoe the horse was lost; For want of a horse the battle was lost; For the failure of battle the kingdom was lost— All for the want of a horseshoe nail.

—English Proverb

The "horseshoe nail" proverb may have its origin in the unhorsing of King Richard III during the Battle of Bosworth Field on Aug. 22, 1485. Richard III's warhorses, according to some accounts, were poorly shod and proved unable to sustain themselves against their rivals. Was it because someone had sabotaged the king's horseshoe nail supply chain? Perhaps in the buildup phase, his forces were unable to acquire sufficient nails and for each horse tried to get by with five nails instead of the requisite eight to 10, leading to poor combat performance in the field?

Nelson *has held a variety of positions in the Department of Defense Office of Manufacturing and Industrial Base Policy since 2006 and has led a number of industry-wide capability assessments. He has more than 30 years of experience in the military, government, and private sector, holds a bachelor's degree in Mechanical Engineering, a master's in Electrical Engineering and is a licensed Professional Engineer.*

The specific details matter less than the central issue: the need for modern armies, including America's, to ensure an adequate and reliable supply of critical warfighting materials long before the outbreak of hostilities. Moreover, this concern applies not just to the big-ticket items—the equivalents of your horses and the armor for them and your horsemen—but includes simpler and more generic items like horseshoe nails. While the former may seem more pressing, it is the latter that more often are neglected, partly because one might assume that simpler components are plentiful in the commercial market and easily adapted to military use.

In today's warfighting environment, planners aren't worried about the availability of horseshoe nails but about items such as thermal batteries needed to ensure that rockets can operate under harsh cold-weather conditions, or the stockpiling of rotary heads for combat helicopters and propeller aircraft. But, just as in Richard III's time, the greatest concern may lie at the more invisible subtier supply level, where items might have dual commercial and military uses. Making an assumption that there is a naturally abundant supply of these items in the open market might result in unforeseen equipment failures, leading to catastrophic battlefield loss.

Fortunately, America's defense planners have learned the lesson of history. The Pentagon is carefully monitoring the gaps and vulnerabilities of the industrial base as a whole. In 1994, the Department of Defense (DoD) established an office, now known as Manufacturing and Industrial Base Policy (MIBP), to monitor production capabilities, stockpiles and supply chain flows and prospective bottlenecks of critical subtier defense items. In 2014, the DoD began a special program, known as Industrial Base Analysis and Sustainment, or IBAS, to fund mitigation of identified industrial base issues. If America goes to war, it wants to be able to surge its forces to match any level of threat. That means ensuring that America's forces have enough of the war supplies they need available on demand at all tiers and that those supplies are reliable and will hold up under the stress of combat.

IBAS follows the Office of MIBP methodology in evaluating risk to the industrial base by assessing both the fragility and criticality of a capability or product. How important is it to defense readiness? In what measure is it vulnerable to loss or disruption?

The sweet spot for the IBAS program is reducing the risk of losing industrial base capabilities that are important but invisible and whose maintenance is under-incentivized. In addition, the goal is not to sustain all capabilities indefinitely but to avoid reconstitution costs when capabilities are likely to be needed in the foreseeable future. IBAS makes investments only when

sustainment is more cost-effective than reconstitution and results in overall cost savings to the DoD.

The three main areas of IBAS focus are:

- Unique Capabilities—Lifelines and safe harbors for critical, unique capabilities with fragile business cases.
- Design Teams—Preserving critical skills for technological superiority.
- Industrial Base Supply, Expansion and Competition—Supporting expansion of reliable sources.

Proposals for IBAS funding are evaluated in a four-step process. First, proposals are scored with established fragility and criticality criteria. Fragility examines characteristics that make a specific capability likely to be disrupted. Criticality examines characteristics that make a specific capability difficult to replace if the capability is disrupted. Second, proposals are reviewed for alignment with IBAS objectives. Third, proposals are ranked by a multi-Service/multi-agency Joint Industrial Base Working Group review panel. Fourth and finally, the Deputy Assistant Secretary of Defense for MIBP evaluates the review panel results and makes the final selections for IBAS funding.

Thus far, IBAS has initiated roughly 20 different projects in various areas. The following are a few representative examples:

Butanetriol. The IBAS program addressed a situation where a prohibited source, China, was a sole-source provider for Butanetriol, a precursor chemical used in solid rocket propulsion that enables smokeless/low-signature operation. Butanetriol is a "fine chemical," the production of which involves dozens of steps that take several months for a single batch. It also is a defense-specific product with little or no commercial application. Annual defense industrial base purchases are substantially less than $5 million per year. As a result, there is no interest among large domestic chemical manufacturers to meet the need. IBAS funds were used to design minor modifications to the facilities of Penn A Kem in Memphis, Tennessee, enabling the first full-rate production of this material in the United States since 2002. This project ensures the sustainment of this capability across many DoD programs including the HELLFIRE air-to-surface missile, Joint Air-to-Ground Missile, the TOW and Javelin anti-tank missiles and Griffin lightweight rocket system.

Infrared sensors. After the Second Generation focal plane array production ended in 2012, funding from IBAS program in 2014 and 2015 allowed key technical personnel of DRS Infrared Sensors & Systems in Dallas, Texas, "to continue advancing the technology base for the Army's Third Generation focal plane arrays," said Shawn Black, vice president and general manager of DRS. "In addition, it has allowed DRS to recruit new critical technical and production personnel in support of this effort." Recognizing DRS' sustained technological capability, the Army on March 16, 2016, announced a contract award to DRS Technologies to develop the Third Generation Forward Looking Infrared in the engineering and manufacturing development phase of the program.

ESAD fuzes. Missiles and many of their subcomponents obviously have no commercial counterparts. At very low production rates, some of these subcomponents are at risk of becoming unsustainable. In many missile systems Electronic Safe and Arm Devices (ESADs) have replaced mechanical fuzes and are one of the at-risk components. In order to ensure a reliable supply of ESADs in the future, IBAS is funding a two-phase project. The primary aim of the first phase is cost reduction. The second phase is meant to increase commonality and expand ESAD usage to higher-production gun-fired and air-delivered munitions. Expanding to additional munitions would improve the overall business case for the subcomponent and thereby improve its sustainability.

A number of industrial base assessments are under way that might well result in new IBAS funding. For example, the microelectronic sector remains an area of priority focus. IBAS has provided critical investments in research and development and in qualification testing to develop trusted foundry technologies. These technologies include focal plane arrays to meet advanced imaging requirements for the space, ground, and aviation sectors, as well as radiation-hardened microelectronics, and a specialized integrated circuit approach to ensure the preservation of strategic national security systems, such as the Trident missile in high-threat environments.

MIBP also is paying increased attention to the problem of single-source vulnerability in the defense industrial base. For a number of critical products or capabilities, the loss of a single supplier could lead to a catastrophic failure of the DoD's ability to supply the warfighter. A fire at a factory in the United Kingdom in February 2015 destroyed the DoD's only source of rotary heads for C-130J aircraft. In these sorts of cases, the DoD especially wants to be able to expand and upgrade the number of defense-unique and defense-focused suppliers. The IBAS program is not intended to rescue individual suppliers. However, in zeroing in on subtier capabilities and the manufacturing processes that sustain them, IBAS invariably becomes involved with a relatively small number of suppliers that might be affected by adverse market or procurement trends. As in the C-130J case, IBAS could play an important role in helping to fund and promote new suppliers on U.S. soil to shore up vulnerable areas in the supply chain.

As the IBAS program evolves to meet its statutory mission, it will increase its focus on innovation, employ the most effective acquisition methods, and seek out non-traditional commercial suppliers. This focus is a clear indication that the DoD cannot afford to consider horseshoe nails a lesser capability—or a strategic afterthought.

For more information, see the website at http://ibasp-public.ria.army.mil/

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Stitching Together the "Digital Thread"

Jacob Goodwin

The Digital Manufacturing and Design Innovation Institute (DMDII) is one of the eight institutes established by a compendium of federal agencies under the umbrella of the National Network for Manufacturing Innovation (NNMI). We think of DMDII as being the institute with the broadest technical jurisdiction—in fact, we like to call our technical focus area "foundational" for all of the other institutes—but it also seems to be the most difficult institute to explain.

Essentially, DMDII has a mandate to expand the field of "digital manufacturing and design," which we describe as the creative use of data at every stage of the manufacturing process in order to move parts and components through their production stages more efficiently, more quickly and less expensively so they can become more competitive in the marketplace and help bring manufacturing jobs back to the United States. Under the

Goodwin *until recently was director of membership engagement for the Digital Manufacturing and Design Innovation Institute in Chicago. He is a former editor-in-chief of a homeland security industry publication and a former sales and marketing executive in the defense, telecommunications and security industries. He authored a book about the Defense Department's weapons procurement process.*

Cooperative Agreement signed in February 2014 by the Chicago-based nonprofit UI LABS, and by the U.S. Army (on behalf of the federal government), we have broken down "digital manufacturing and design" into four separate "Technical Thrust Areas," including:

■ **The Advanced Manufacturing Enterprise**, which is the digital thread of the transfer of data from one stage of production to another. For example, the communication of digital data developed by a part designer on a Computer Aided Design (CAD) system to a separate Computer Aided Manufacturing (CAM) system used on the manufacturing floor. DMDII looks at the gaps between different stages of production—and the impediments to interoperability that plague these systems—and tries to find ways to make the digital thread more efficient and more seamless.

■ **Intelligent Machining** is the aspect of manufacturing that places sophisticated sensors on an individual piece of manufacturing equipment on the factory floor in order to assess that equipment's performance in real time. By monitoring a piece of equipment's through-put, temperature, lubrication, vibration, scrap rates and many other performance characteristics—and analyzing that data quickly—intelligent machining software and tools can determine when the machine is operating at less than optimal levels. Ideally, the intelligent machining software can adjust the performance of the machine in real time and bring it back into specifications.

■ **Advanced Analysis** is the niche within advanced manufacturing that examines mountains of "Big Data," with an eye toward deriving new insights from the data that can lead to improvements in design and production processes. Sometimes, this field includes the use of Big Data, coupled with high-powered computing resources, to offer modeling and simulation capabilities to a manufacturer that it could never achieve on a manual basis.

■ **Cyber Physical Security**, a topic that has become increasingly prominent in the years since DMDII was established, involves the protection of production equipment on the factory floor from harm that could be caused by hackers with malicious intent. The damage might take the form of piracy of proprietary intellectual property (IP) residing on a specific piece of manufacturing equipment, or the operation of the machine itself could be subverted by hackers who want to alter the characteristics and performance of specific manufactured parts. (Imagine the dimensions or strength of a critical component of an aircraft engine being compromised by a hacker.)

DMDII's Mission

DMDII is expected to advance the field of digital manufacturing and design throughout the United States. We strive to accomplish this ambitious goal in three fundamental ways:

(1) Applied Research and Development (R&D). Our institute is responsible for identifying the technical challenges we pose to our industry and academic members; developing the formal solicitations we publish to invite teams to submit their proposed technical solutions; evaluating the white papers we receive from self-formed proposal teams; selecting the most promising technical approaches; negotiating R&D contracts with the selected teams; signing contracts with the "team leads," and managing the progress of individual R&D projects as they proceed.

To date, DMDII has announced the award of 18 separate R&D projects valued at $34 million, with many more in the pipeline. These publicly announced projects have distributed prime contracts and subcontracts to more than 60 unique industry and academic organizations across the United States.

These topics typically are too complex to be tackled by any single organization in the manufacturing sector. They generally require the combination of skills and resources that can only come from teams of large and small companies, software developers, and leading research universities. Fortunately, since DMDII was established in early 2014, we have attracted more than a dozen multibillion-dollar, multinational corporations as industry partners (including Boeing, Caterpillar, Dow Chemical, Faurecia, General Electric, Illinois Tool Works, John Deere, Johnson and Johnson, Lockheed Martin, Microsoft, Procter & Gamble, Rolls-Royce, and Siemens).

In addition, we have signed to our consortium more than 120 small- to medium-size manufacturers and not-for-profit organizations, as well as more than 40 leading research universities.

(2) Technology Transition. This has two key components. DMDII takes steps to make the intellectual property developed and/or matured during an R&D project better prepared for commercialization. This requires us to push the project beyond the realm in which we usually operate (Technology Readiness Levels [TRLs] 4 through 7) to even higher TRLs, where the newly developed technology becomes ready to be introduced into the marketplace.

We spend time and money perfecting a product's design, building prototypes of it, testing it in laboratory conditions, and then testing it in real-world conditions. Our institute has come to recognize that if we are to achieve lasting value in the manufacturing sector, we need to provide guidance, a framework, and a process to propel our most-promising projects closer to commercialization.

That's one side of the "Technology Transition" coin. The other side involves encouraging all manufacturers, especially the small- and medium-sized enterprises (SMEs) to embrace these new digital manufacturing and design technologies in their own factories. Given the fast pace that SMEs must maintain to meet their day-to-day obligations with limited staffing, dedicating time to planning for the future can seem a luxury—however necessary it may be to maintain the company's competitiveness.

(3) Workforce Development. Here is a final ingredient in our model and includes training and educating workers to acquire the skills they'll need to operate in a digitized factory environment. Specific to operators, administrators, and executives, DMDII works with its network of industry partners to identify the job profiles specific to digital manufacturing and design.

This is a highly complex task. To be clear, we are not the folks who will actually train the workers of the future. Instead, DMDII is assigned the mission under the Cooperative Agreement to "architect" a U.S. workforce development plan. With the assistance of a workforce advisory committee, including some of our key industry and academic members, we help determine what kinds of curricula (at what educational levels) need to be developed; on what platforms the training should be delivered (face-to-face traditional classroom instruction, massive open online courses, or "MOOCs," video instruction, etc.); and to whom it should be delivered (high schools, community colleges, universities, vocational schools, and/or manufacturing companies).

DMDII Projects and Value to Partners

Applied R&D projects are central to the DMDII process, but partners also see value in the institute's wide-ranging network, idea and thought leadership generation, and the possibilities that surround the adoption of new technologies.

DMDII, using experts from our industry, academic, and government partners, created a digital roadmap for the institute, highlighting the gaps and necessary building blocks for digital manufacturing adoption. "Enterprise projects" come from this strategic roadmap and leverage government and private funds together with at least a 1-to-1 ratio of private to government funding. All of our DMDII partners benefit from the shared risk from this leveraged R&D.

Our other project category is dubbed "partner innovation projects." These are entirely partner led and are often more specific to problems experienced by that partner. Using our framework, network, and innovation processes, we help partners pull together unique teams and solutions that would be difficult to source individually. The project partners once again determine and own the resulting IP and the pathway to commercialization.

Now 2 years old, the DMDII is a relative newcomer to the decades-old manufacturing industry, but the model—with its strong emphasis on partnership building, technical collaboration, and shared risk—has the potential to be a catalyst that transforms American manufacturing by creating outcomes and assets that can be used by the entire industry's transition to a digital era.

See the website at http://dmdii.uilabs.org/.

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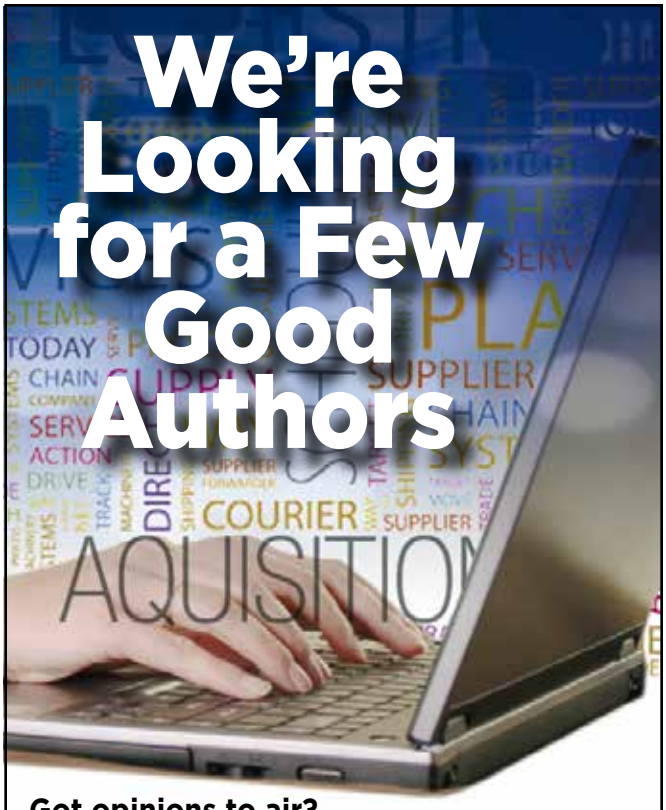

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Write an article (1,500 to 2,500 words) and *Defense AT&L* will consider it for publication. Our readers are interested in real-life, hands-on experiences that will help them expand their knowledge and do their jobs better.

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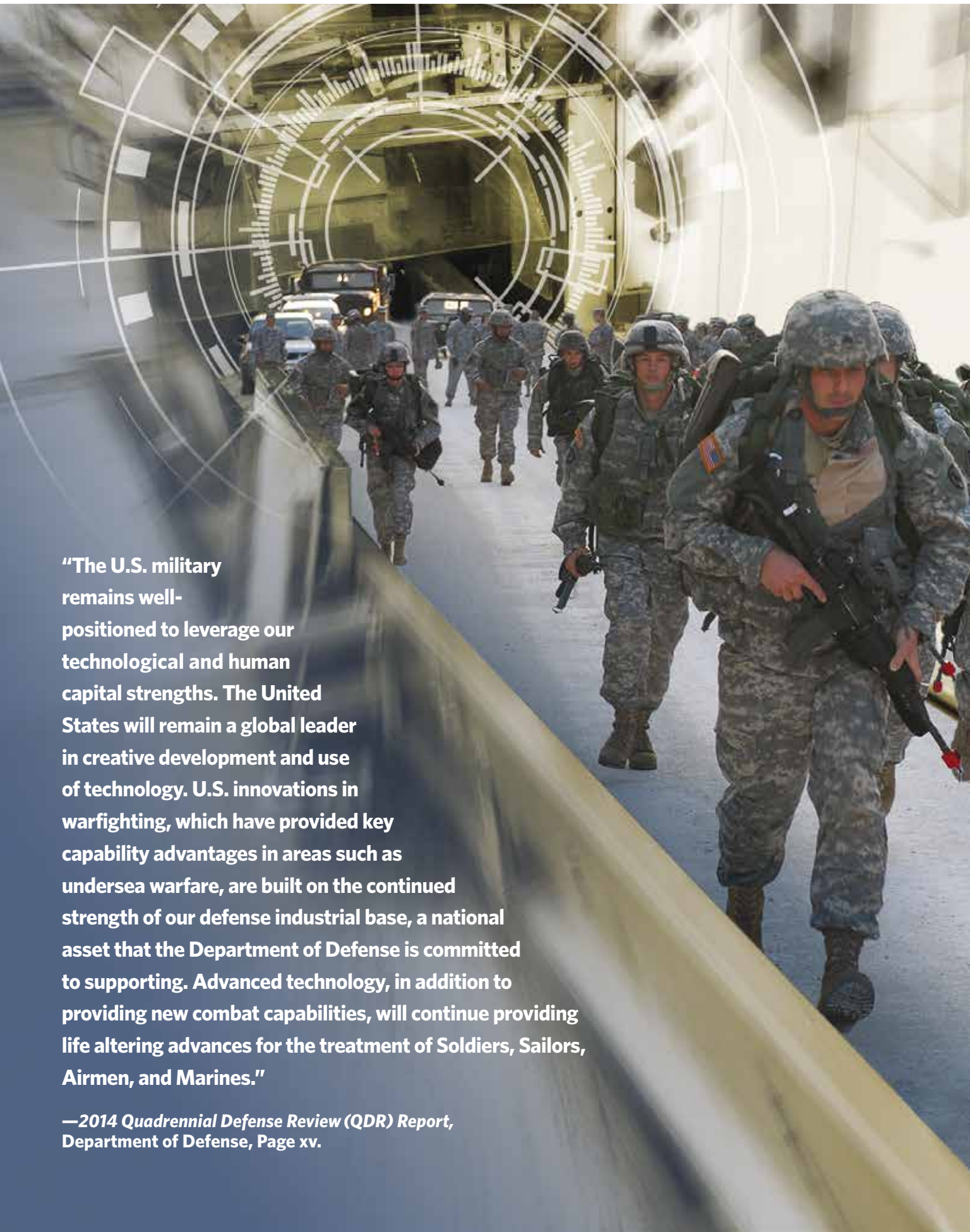


"The U.S. military remains well-positioned to leverage our technological and human capital strengths. The United States will remain a global leader in creative development and use of technology. U.S. innovations in warfighting, which have provided key capability advantages in areas such as undersea warfare, are built on the continued strength of our defense industrial base, a national asset that the Department of Defense is committed to supporting. Advanced technology, in addition to providing new combat capabilities, will continue providing life altering advances for the treatment of Soldiers, Sailors, Airmen, and Marines."

—2014 Quadrennial Defense Review (QDR) Report,
Department of Defense, Page xv.

Manufacturing Technology Program

Bringing Innovations to the Warfighter

Tracy Frost ■ *Scott Frost*

Providing warfighters with cutting-edge capabilities in a timely manner means turning scientific discoveries or inventions into affordable, operational and integral products. The Department of Defense (DoD) Manufacturing Technology (ManTech) program serves as an enabler of technology transition by bringing affordable technologies to acquisition program managers through new manufacturing and production processes and systems.

Defense acquisition programs rely on innovative manufacturing capabilities and an industrial base that can use these capabilities to deliver products that meet the needs of the warfighter. In the 20th century, when the threat was highly predictable and the U.S. defense industrial base was largely self-contained, ManTech helped keep the nation positioned to produce the best military systems in the world. In the 21st century, the DoD faces a range of strategic, conventional and asymmetric challenges while the U.S. technological advantage is under strain and the defense industrial base is increasingly reliant on commercial capabilities. To address these challenges and equip America's warfighters, program managers are tapping a globally networked and diverse industrial base. Compounding this complexity is the increasing imperative to consider affordability in the DoD's science and technology, acquisition and sustainment plans. These are the new demands placed on defense manufacturing, and they are shaping the role of ManTech.

The program looks beyond the normal risk of industry and directs investments at improving the quality, productivity, technology and practices of businesses and workers that provide goods and services to the DoD. ManTech focuses on enabling the affordable and timely development, production and sustainment of defense systems, thereby enhancing our technological edge in a dynamic, diverse and evolving threat environment.

Tracy Frost *joined the Department of Defense (DoD) Manufacturing and Industrial Base Policy (MIBP) office in 2015 and currently serves as the director of Manufacturing Technology. She leads the Defense-wide Manufacturing Science and Technology Program investment portfolio, including the DoD Manufacturing Innovation Institutes funded within that portfolio.* **Scott Frost** *is a principal analyst and program manager at ANSER, a not-for-profit public service corporation. Since 2008, he has been responsible for leading the development of, and updates to, the DoD ManTech Program Strategic Plan on behalf of the Office of the Secretary of Defense (OSD)/MIBP ManTech office and the Joint Defense Manufacturing Technology Panel, and for overseeing ANSER's overall planning, policy and analytical support to the OSD/MIBP ManTech office.*

The DoD ManTech Program is administered for the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L]) by the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (MIBP) who exercises Office of the Secretary of Defense (OSD) oversight of the ManTech program. ManTech includes component programs individually executed by OSD and the Army, Navy and Air Force, the Defense Logistics Agency (DLA) and the Missile Defense Agency (MDA). Although all Component ManTech programs work in concert toward common goals, each has important focus areas to meet individual Component mission needs.

integrated approaches to maintaining the full suite of necessary defense manufacturing enterprise capabilities.

The Joint Defense Role

The component ManTech programs collaborate and coordinate their efforts through the Joint Defense Manufacturing Technology Panel (JDMTP). The principals of the JDMTP are senior technology managers representing the Army, Navy, Air Force, DLA, MDA and OSD. The JDMTP categorizes ManTech investment areas by the technology portfolios of subpanels. The current subpanels are Electronics, Metals, Composites and Advanced Manufacturing Enterprise—

With a combined investment of $14.5 million, these initiatives are projected to reduce F-35 program costs by $1.1 billion over 30 years of production.

The Army ManTech Program is structured around enabling manufacturing improvements of components and subsystems for ground, soldier/squad, air, lethality and command, control, communications and intelligence systems.

The Navy ManTech Program's critical goal is to reduce the acquisition cost of current and future platforms, resulting in an affordability investment strategy currently focused on five ship platforms and the F-35 and CH-53K aircraft.

The Air Force ManTech Program is the DoD's lead for manufacturing technology in aerospace propulsion, structures and intelligence, surveillance and reconnaissance and is the only Air Force corporate program working strategic issues and opportunities in manufacturing and industrial readiness. Manufacturing technology plays a pervasive role in enabling many Air Force Science and Technology Strategy priorities, chiefly through attaining next-generation agile manufacturing.

The DLA ManTech Program focuses on sustaining the warfighters and improving materiel readiness. Ongoing efforts support improvements in availability of microcircuits, combat rations, clothing and protective equipment, batteries, forgings and castings.

The OSD-managed Defense-wide Manufacturing Science and Technology (DMS&T) Program takes a broad, overarching view toward closing critical gaps in cross-cutting, military manufacturing enabling technologies that will have significantly impact multiple Military Departments or platforms.

In particular, MIBP has the organizational visibility and access to policy and investment levers to enable more coherent and enabling Component ManTech programs to maximize opportunities for shared investment in initiatives and strategies with joint application and preventing duplication of effort.

The JDMTP is moving forward with joint planning and coordination on major weapon systems, including the F-35. In the case of the F-35 Lightning II, four ManTech projects (two Navy and two Air Force) directly affected F-35 affordability. With a combined investment of $14.5 million, these initiatives are projected to reduce F-35 program costs by $1.1 billion over 30 years of production. More importantly, these technology advances can be leveraged by current and future defense programs to reduce costs and bolster U.S. manufacturing capabilities.

Other successful ManTech projects include:

- The Large Affordable Substrates project provides a domestic source of cadmium zinc telluride wafers for military critical infrared focal plane arrays.
- The Chip Scale Atomic Clock program enables affordable, precise timekeeping within C4ISR (command, control, communications, computers, intelligence, surveillance and reconnaissance) systems in GPS-denied environments by reducing unit cost from $8,700 to $400, enabling production to increase from 10 per year to 40,000 per year. Potential savings are projected to approach $300 million.
- The Cold Spray Deposition project creates an automated repair cell, which increases flight readiness rates for Navy and Marine helicopters. Presently, parts are scrapped, increasing sustainment cost and stressing a casting industrial base with long lead times. The savings for the CH-56 Helicopter program alone is projected at $100 million annually.

- Virginia Class Submarine (VCS) initiative: 31 of the Man Tech affordability projects have been implemented or are in process. Realized cost savings per hull of more than $27.7 million have been recognized by the Virginia Class Submarine Program Office and General Dynamics Electric Boat.

The DMS&T Program: Underpinning DoD's Manufacturing Innovation Institutes

In addition to its broad DoD ManTech Program oversight responsibilities on behalf of the USD(AT&L), the OSD ManTech office housed in MIBP also oversees and executes the DMS&T program component of the DoD ManTech Program. The DMS&T program is an important joint enabler that complements each Service's and agency's ManTech program. It focuses on broad, cross-cutting defense manufacturing needs—those that are typically beyond the ability or risk of a single Military Service or agency to address and to stimulate the early development of manufacturing processes and enterprise business practices concurrent with S&T development to achieve the largest cost-effective impact.

It was out of the DMS&T program that the seeds were planted for the DoD to embrace industry and academia in broader public-private collaboration to enhance national manufacturing capabilities, including those with likely defense applications. In 2012, the DoD was asked to be one of the leads in an effort to create a National Network for Manufacturing Innovation program. This program seeks to create a robust national innovation ecosystem composed of a growing network of regionally based but nationally impactful Manufacturing Innovation Institutes across the United States. Each has a technical focus area of high importance to both the federal government and to industry.

ManTech's Legacy

The DoD ManTech program is a highly versatile R&D investment program that can serve as that key focal point to bring attention and technological resources to bear on the DoD's most pressing requirements for affordable modernization and sustainment. It ensures the health and resilience of the defense industrial base—thousands of diverse companies providing products and services, directly and indirectly, to national security agencies.

ManTech is an increasingly critical underpinning of the DoD's strategy to affordably develop, produce, field and maintain high-quality equipment and systems to meet 21st-century national security challenges. The DoD ManTech program does just that—bringing affordable, defense-critical manufacturing technologies to acquisition and sustainment managers and bridging the gap between technology discovery and the delivery of new capabilities to the warfighter.

More information and contacts can be found at www.dodmantech.com.

The authors can be contacted at **tracy.g.frost.civ@mail.mil** *and* **scott.frost@anser.org**.

When America Makes, America Works

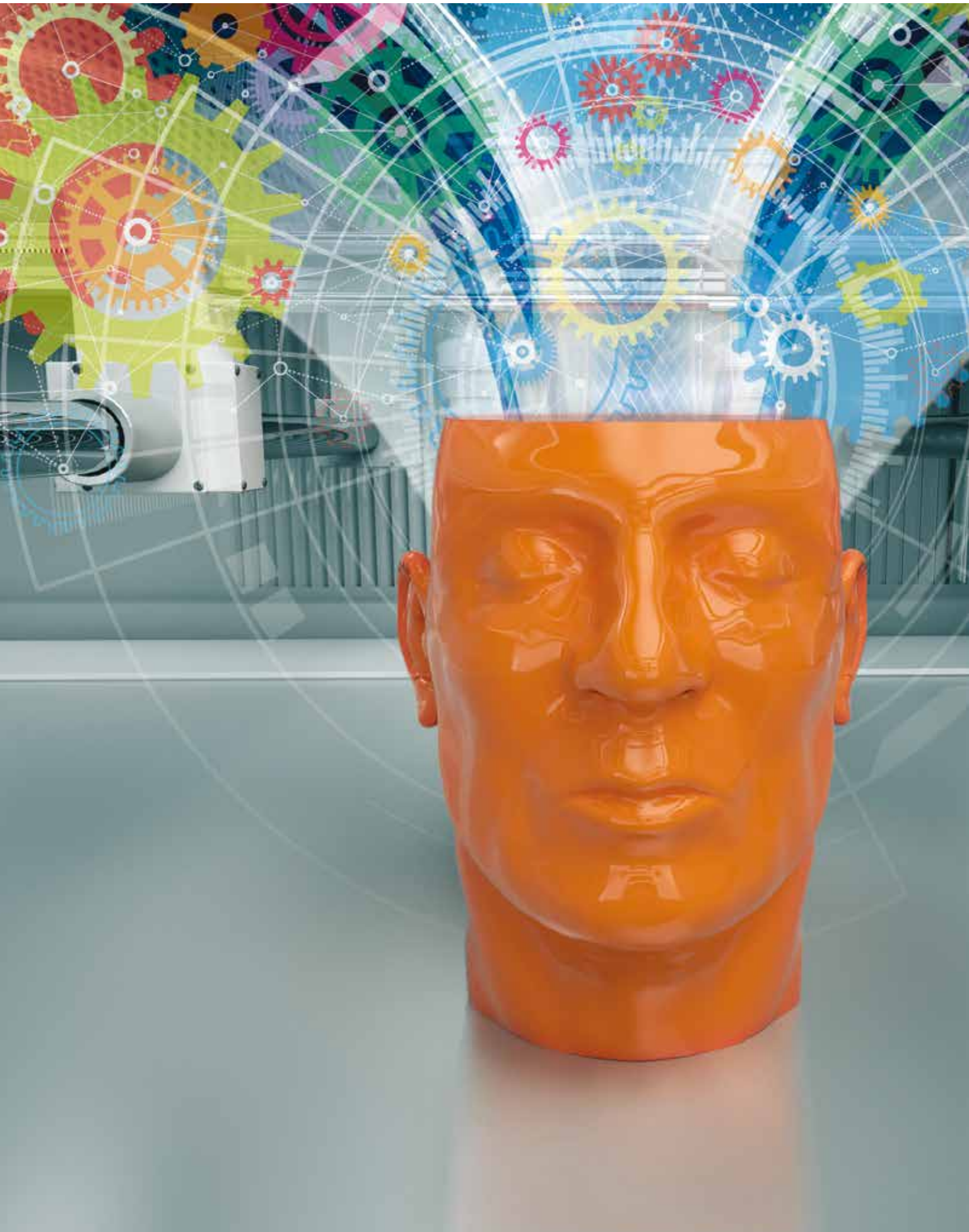
A Successful Public-Private 3D Printing (Additive Manufacturing) Partnership

Jennifer Fielding, Ph.D. ■ *Ed Morris* ■ *Rob Gorham* ■ *Emily Fehrman Cory, Ph.D.* ■ *Scott Leonard*

America Makes is the National Additive Manufacturing Innovation Institute, a public-private partnership led by the National Center for Defense Manufacturing and Machining (NCDMM), a not-for-profit 501(c)3 organization. The vision for America Makes is to accelerate additive manufacturing (AM) innovation to enable widespread adoption by bridging the gap between basic research and technology commercialization.

America Makes fosters collaboration between its more than 170 member organizations, which include large and small businesses, universities, community colleges, economic development organizations, manufacturing extension partnerships (MEPs), federal laboratories and other federal partners. Membership has grown by about 40 percent annually, and more than 60 members are small businesses.

Fielding *is the government program manager for America Makes and a branch technical adviser within the Air Force Research Laboratory Manufacturing and Industrial Technologies Division at Wright-Patterson Air Force Base in Dayton, Ohio.* **Morris** *is vice president and director of America Makes within the National Center for Defense Manufacturing and Machining (NCDMM) in Youngstown, Ohio.* **Gorham** *is the director of operations for America Makes within the NCDMM.* **Fehrman Cory** *is the deputy program manager for America Makes from the Air Force Research Laboratory Manufacturing and Industrial Technologies Division at Wright-Patterson.* **Leonard** *is a program management consultant with D.K. Jones Consulting LLC in Beavercreek, Ohio, and is an advisor to the government partners for America Makes and other Manufacturing Innovation Institutes.*



America Makes Vision:

Accelerate additive manufacturing innovation and enable widespread adoption by bridging the gap between basic research and technology development and deployment

The institute's Innovation Factory headquarters was launched in September 2012 in Youngstown, Ohio. The institute quickly finalized its operating structure and membership agreement in November 2012, and this includes the successful intellectual property model still in use today. The institute continues to expand. In 2015, America Makes launched a pilot satellite center at the University of Texas in El Paso, a center of innovation for additive manufacturing in a region of opportunity for economic and workforce development.

The Public-Private Partnership—A Model for Innovation

A combined public and private investment is the most efficient and effective method to enable U.S. federal agencies, industry, and academic institutions to collaborate and coordinate on the three main focus areas of America Makes: Technology Development, Technology Transition and Dissemination, and Workforce Development. The public-private partnership is implemented through a Cooperative Agreement with the Air Force Research Laboratory on behalf of the Office of the Secretary of Defense, Manufacturing and Industrial Base Policy. America Makes' federal partners include the Department of Defense (DoD), the Departments of Energy, Commerce, and Education, as well as NASA, the National Science Foundation, Federal Aviation Administration, and the Food and Drug Administration (FDA).

The America Makes public-private partnership is a collaboration that goes well beyond co-investment of funds. The organizational structure of America Makes embeds dozens of government employees in the ongoing operation of the institute. For example, the Air Force program management team collaborates with the America Makes management team almost daily to work on both strategic and tactical level issues. In addition, the organization receives advice on program-level issues from the Government Partners Advisory Committee, a team of about 16 government subject-matter experts representing all of America Makes' government partners. Finally, government personnel participate on America Makes' numerous advisory groups and working groups that address topics such as technology roadmapping, weapon system sustainment, and technical standards.

The public-private partnership enabled America Makes to convene diverse groups to address broad needs of the additive manufacturing community. For example, America Makes facilitated the creation of a joint DoD technology roadmap for additive manufacturing through a series of workshops that brought together experts from the Air Force, Army, Navy, and the Defense Logistics Agency. Seeing the critical need for industry-led standards, America Makes is partnering with the American National Standards Institute and all relevant standards development organizations to coordinate the development of industry standards.

Another important aspect of the America Makes public-private partnership is that it allows all government services and agencies to work with America Makes to address their needs relative to 3D printing research, development and workforce training. Several government organizations already have worked with America Makes this way by funding more than $20 million in agency-directed projects. Projects are competed among members to identify the best team and technical approach. If the project has potential for broad commercialization, industry may match the government funding with a significant cost share. Many projects address the needs of multiple government organizations, and those organizations may choose to leverage their efforts by co-funding a project while avoiding redundant investments. Funding organizations maintain full control of the project's statement of objectives, proposal selection, and project oversight. Because of the America Makes process for solicitations, projects frequently are performed by multiple team members representing all essential supply chain levels, and this accelerates technology transition and creation of production supply chains.

For industry partners, the ability to spread the cost share across the members of the project team further reduces their individual risk and increases their return on investment. Several large business members report they are realigning their internal research and development investments with the America Makes technology investment roadmap. This business model aligns well with the DoD's Better Buying Power 3.0 initiative to increase the productivity of industry independent research and development and contracted research and development. With the combined and integrated public and private investments, America Makes is establishing a culture of collaboration that is developing into a strong engine for innovation and technology commercialization in the United States.

Technology Development

Additive manufacturing, more commonly known as "3D Printing," is a suite of emerging technologies to fabricate metallic, plastic, ceramic and electronic parts for applications as diverse as lightweight aerospace structures and custom biomedical implants, all using a layer-by-layer technique, in which

material is placed precisely as directed from a 3D digital file. Additive manufacturing is a game-changing technology for both the U.S. manufacturing economic engine and the defense industrial base that allows production of new and enhanced products that cannot be made using traditional manufacturing techniques. Additive manufacturing is an enabling technology for the military, potentially allowing spare parts to be built or platforms to be repaired in-theater, which will make possible last-minute design adjustments to respond to mission changes, and reduce the cost of building complex parts.

America Makes has a portfolio worth more than $96 million in public and private funds invested in advancing the state-of-the-art in additive manufacturing. To achieve these technical advancements, project teams frequently are self-organized as supply chains, including technology innovators, material suppliers, equipment producers, and large system integrators. This team structure facilitates technology transition into production by ensuring that requirements are understood at all levels in the supply chain. Here are just a few examples of recent technology development and dissemination success stories:

Impacting Medical and Aerospace Sectors with High Performance Polymers. A team led by Northrop Grumman, in partnership with small business and part manufacturer Oxford Performance Materials (OPM), demonstrated a high-performance polymer as a viable material choice for air and space vehicle applications. OPM's material became the first polymeric additively manufactured material to receive FDA approval for cranial, facial and spinal implants (2015) and the results from this project are on track for transition into major defense system programs in 2016.

Bringing Additive Manufacturing Options to Small Machine Shops. Small business member Optomec, along with MachMotion and TechSolve, developed a modular kit to retrofit any computer numerical control (CNC) machine to create a hybrid machine with additive manufacturing capabilities. Now these hybrid CNC/additive manufacturing machines can perform both additive and traditional subtractive processes on a metal part. This achievement

America Makes has more than 170 organizational members, comprising:

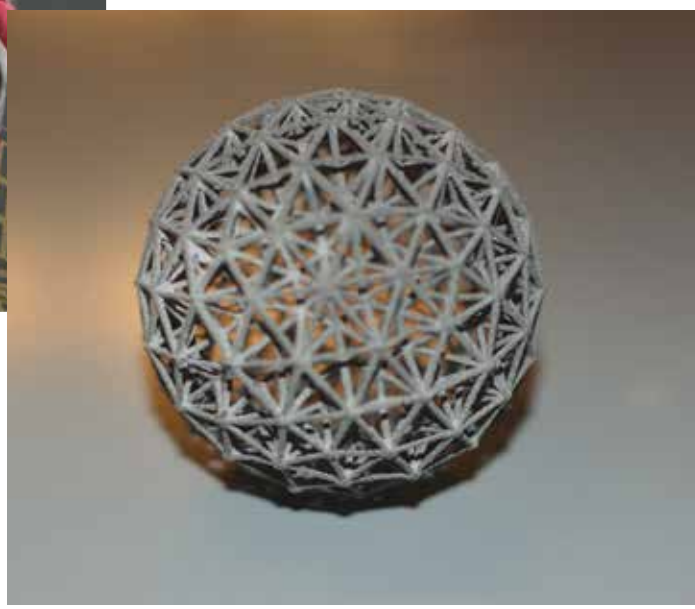
- Large Businesses
- Small businesses (over 60)
- Universities
- Community colleges
- Economic development organizations
- Federal laboratories
- Other federal partners

The America Makes Innovation Factory is a center for immersive training for the 3D printing workforce.

All photos courtesy of the National Center for Defense Manufacturing and Machining

Left: A possible future engineer studies a model of an envisioned Mars-based habit as it is constructed by a 3D printer.

Below: 3D printing can produce complex shapes and structures that cannot be made using traditional manufacturing methods. A lattice stucture is ideal for maintaining performance with lighter weight.



"America Makes is invaluable for helping community colleges understand what workforce skills are in demand."

—Vice president for Strategic and Institutional Development at a regional member community college

"America Makes is having an extraordinary impact on our region. Youngstown has a new confidence. Local government is working with universities and local businesses more. Youngstown State University is proud to have America Makes nearby, and it is now part of our student recruiting story."

—Jim Tressel, president, Youngstown State University

enables manufacturers and machine shops to adopt additive manufacturing technologies at a fraction of the cost—for a 60 percent savings compared to purchasing a new additive manufacturing machine with equivalent capabilities. This product now is commercially available and has been purchased by DoD suppliers.

Additive Manufacturing Transforms Metal-Casting Industry. Youngstown Business Incubator, in partnership with Youngstown State University in Ohio and major industrial partners, developed a methodology for additive manufacturing of sand-cast molds, built regional supply chains for multiple materials, developed two domestic sources for resins and cleaners, and reduced the cost of printing materials by more than 80 percent. The team partnered with the American Foundry Society to reach more than 800 metal-casting companies with the technology. Technology transition applications include fuel system components for multiple major defense and automotive part suppliers. An automotive part was especially difficult to produce as an eight-piece assembled sand cast tool, prone to breakage upon assembly. The additively manufactured sand core tool was able to be produced as one part and improved yield from 12 percent to more than 99 percent, while also reducing the manufacturing lead time by 70 percent. Adoption of this technology is making these small manufacturers globally competitive for producing advanced, complex metal castings.

Members of America Makes value the opportunities to network and build project teams and supply chains.

Workforce Development and Educational Outreach

Additive manufacturing is a fast-growing manufacturing trend and calls for new ways to educate and train both the workforce. America Makes has partnered with stakeholders to build a comprehensive workforce and education roadmap to address training needs. "America Makes is invaluable for helping community colleges understand what workforce skills are in demand," said the vice president for Strategic and Institutional Development at a regional member community college.

Every America Makes technology development project includes an integrated workforce activity with clear training deliverables. Some of the many workforce development success stories include:

America Makes partnered with Deloitte Consulting, Marquette University, Oak Ridge National Laboratory and 3D Systems to create a free Massive Open Online Course in additive manufacturing business fundamentals. It is designed to help educate the market on the business drivers of additive manufacturing. More than 14,000 participants have been trained so far.

America Makes partnered with the Veterans Administration for a Prosthetics and Assistive Technologies Challenge, which enabled a wide range of additively manufactured devices to be developed to help injured veterans conquer daily challenges. This led to a follow-on project funded by Google.org to develop training for returned military veterans to learn the basics of creating personalized assisting technologies using 3D printing, rapid prototyping, and scanning technologies.

America Makes launched the first-ever additive manufacturing certificate program in partnership with the Milwaukee School of Engineering and the Society of Manufacturing Engineers. The certificate program expands the students' knowledge of additive manufacturing technologies and provides a portable, authenticated career credential and has awarded more than 200 certificates so far.

Regional and Supply Chain Impact

The creation of America Makes accelerated the clustering of advanced manufacturing and economic development within the region. Youngstown Business Incubator (ranked the Number One university-associated business incubator in the world by the University Business Incubator Index), in partnership with America Makes, received funds for renovating a fifth building within its downtown complex for incubation of additive manufacturing startups. This economic revitalization and the local opportunities it has created are drawing key startups and entrepreneurs to the area and building the regional supply chain.

"America Makes is having an extraordinary impact in our region," said Jim Tressel, president of Ohio's Youngstown State University. "Youngstown has a new confidence. Local government is working with universities and local businesses more. Youngstown State University is proud to have America Makes nearby, and it is now part of our student recruiting story."

Conclusion

America Makes has shown its ability to convene the additive community within a public-private partnership model to drive an innovation economy forward for the nation. Additive manufacturing is a game-changer because it brings a whole new set of rules to multiple industry sectors, from aerospace and defense solutions to lifesaving medical applications. It also is an incredibly powerful teaching tool to reinvigorate Science, Technology, Engineering and Mathematics—or STEM—education in the United States. The opportunity of additive manufacturing along with the success of America Makes' public-private partnership structure is playing a critical role in developing additive manufacturing for advanced defense capabilities and growing a manufacturing-driven economy.For more information, see www.americamakes.us.

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The Breath of Life

Rising From the Valley of Death

Melinda Woods

When you come home tonight and turn on your LED lights, you can thank the Defense Production Act (DPA) Title III Program of the Department of Defense (DoD).

In 2006, the DoD began looking for ways to reduce the cost of silicon carbide (SiC), an important but expensive material used for semiconductor electronic devices that operate at high temperatures or high voltages. By assessing the industry that created these devices, the Title III Program determined that the indoor LED lighting technology and the semiconductor electronics device utilized the same SiC material. The Title III Program concluded that the expansion of LED production would drive down costs for the military's devices. The DPA Title III Program partnered with the leading LED lighting company and dramatically expanded its LED manufacturing line, which used the same production line required for the military devices.

So what is the DPA Title III Program? Its specific mission is to help bridge the gap between prototype development and production. The DPA Title III Program is distinct from other research and development (R&D) funding

Woods *is the director of the Defense Production Act Title III Program within the office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (DASD[MIBP]). She previously was the assistant director of strategic programs and was action officer team lead conducting Department of Defense reviews on foreign investment. Earlier, Woods was technical advisor for the Defense Technology Security Administration and an analyst at Defense Intelligence Agency. Prior to her public service career, she worked for various semiconductor companies. She is an electrical engineer who received a B.S. and M.S. in Electrical Engineering from the University of Michigan and the Georgia Institute of Technology, respectively.*

authorities because it provides the incentives to companies to create, maintain or expand any domestic production capability needed for national defense. Enacted to support the rapid production of domestic materials during the Korean War, Title III investments played a vital role in the establishment of the domestic manufacturing capabilities in aluminum and titanium.

TITLE III: Presidential Approval Required

Title III is such a unique and critical funding authority that each proposed project requires case-by-case approval by the President himself. Specifically, the President must make a determination in writing that:

- The industrial resource, material or critical technology item is essential to the national defense.
- Without presidential action, U.S. industry cannot reasonably be expected to provide the capability for the needed industrial resource, material or critical technology in a timely manner.
- Purchases, purchase commitments or other action are the most cost-effective, expedient and practical alternative methods for meeting the need.
- Title III purchases, purchase commitments, or other actions are the most cost effective, expedient, and practical alternative method for meeting the need.

Title III incentives are especially appropriate for companies that have made the R&D efforts to create a product but lack an on-ramp for commercialization, a situation that some have termed the "valley of death." DPA Title III breathes new life into the R&D efforts, creating the necessary manufacturing capability and matching the product with the DoD buyer. In many cases, a supplier develops a promising new technology and demonstrates it to a DoD customer. The customer wants to obtain the technology but cannot commit to a product that has yet to be produced in volume. The supplier is unwilling or unable to commit to the investment needed to establish production. Neither customer nor supplier can accept the risk. As a result, the technology, and in some cases the company, can no longer survive on its own.

The Title III process effectively addresses the "valley of death" problem. While many government organizations fund R&D and many others buy high-tech items, the Title III Program has the authorities to bridge the gap between the prototype and full-scale stages of production.

Looking Ahead

This could prove to be a banner year for the expansion of Title III. The 2014 reauthorization allowed Title III to make

Title III: A Record of Success

In recent years, Title III has played an instrumental role in supporting cutting-edge, high-impact defense capabilities based on successful DoD/commercial industry collaboration:

Title III recently helped expand the U.S. domestic industrial base capability for the production of large aerospace composite products employing advanced fiber placement technologies. The newly installed production platform generated in excess of 123 separate parts equating to more than 30 complete F-35 aircraft wing sets while achieving a zero part defect rating. The project also supports the F-18 and advanced naval warfare communications.

Title III also helped expand the domestic production capacity of carbon dioxide (CO_2) absorbent products and develop improvements for several CO_2 absorbent applications. It is used in military scuba, submarine, space, anesthesia, firefighting and rescue applications to "clean" CO_2 from air needed for breathing. Compared with previously used absorbent products, the emergency CO_2 absorbent curtains used onboard military submarines allow significant space savings, longer product life, easier and safer product handling, and reduced product life-cycle cost.

Title III also plays a critical role in the expansion of space and satellite capabilities. The DoD approved in 2011—and revised and upgraded in 2015—a Title III project that covered a wide range of newly enhanced components, including semiconductor imagers, solar cells and cadmium zinc telluride substrates. These components enhance the capabilities of unmanned aerial vehicles (UAVs) and intelligence, surveillance and reconnaissance (ISR) functions such as imaging, geospatial awareness, intelligence and weather monitoring and missile defense. Many of these recommendations came from a DoD-supported Space Industrial Base Council that is fast-tracking the space and missile sector.

The F-35 Lightning II Joint Strike Fighter.
Department of Defense photo

provisions for the increased use of emerging technologies in security program applications and the rapid transition of emerging technologies from government-sponsored R&D to commercial applications—and from commercial R&D to national defense applications. This evolution dovetails with important DoD strategic initiatives such as "Better Buying Power 3.0," which fosters public-private sector partnerships in defense innovation.

Title III also has started to partner with nonmilitary agencies. In partnership with the Department of Energy, Title III has begun a project to scale up production capacity for biofuels. The Department of Homeland Security has partnered with Title III to define projects that will establish affordable production of technologies to protect critical U.S. equipment shipped overseas.

In today's complex and far-reaching threat environment, Title III of the Defense Production Act has become a vital tool for the DoD. The program protects vulnerable sectors of the industrial base and ensures that advanced defense capabilities are fully integrated into our weapons systems. Title III is part of the expanding future of American defense innovation that will preserve our technological superiority—on the battlefield and off.

See website: http://www.dpatitle3.com/dpa_db/.

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Defense AT&L Magazine—A Multiple Winner

Defense AT&L magazine, published by the Defense Acquisition University (DAU), recently won two more awards for publication excellence.

The National Association of Government Communicators (NAGC) at its June 8 meeting awarded *Defense AT&L* its second-place award in the magazine category. Also in June, the magazine for the third consecutive year won an APEX Award for Publication Excellence in the category of magazines of 32 pages or more per issue.

DAU President James Woolsey said, "*Defense AT&L* has long been and continues to be an important way to get information to the workforce and to share insights and ideas. The magazine does this in a compelling and professional way, demonstrating the high standards we have at DAU, as well as the professional commitment of our professors and the broad Defense Acquisition Workforce to sharing, and learning, and improving acquisition outcomes."

The NAGC judges for the 2016 Blue Pencil & Gold Screen Awards included representatives of private industry, consultants and research organizations as well as federal, state and local agencies. There were 265 entries in all categories. NAGC, with offices in Falls Church, Virginia, is an association of public information officers, spokespersons, social media developers and managers and graphic designers and other government communications specialists.

The 28th APEX Competition for Communications Professionals received more than 1,600 entries. The judges included editors, publishers and consultants. The APEX awards are an annual event sponsored by the editors of *Writer's Web Watch*, published by Communications Concepts Inc., a consulting group in Springfield, Virginia.

Both awards name *Defense AT&L* Managing Editor Benjamin Tyree, Art Director Tia Gray and the Editorial and Production Staffs and Art and Graphics Team of the DAU Visual Arts and Press department headed by Randy Weekes. Those staff contributors to *Defense AT&L* include Copy Editor and Circulation Manager Debbie Gonzalez; Production Manager Frances Battle; and Noelia Gamboa and Michael Shoemaker, who provide online and editing support, respectively. Collie Johnson adds extra information to *DAT&L's* online site.

Judges in the NAGC competition praised the writing, editing and graphics of *Defense AT&L*. One judge from NASA wrote: "All three selections showed a very creative and visually appealing layout. The publication overall was a fascinating analysis of complex subjects and very readable" and "Very nice publication for a small staff. The images illustrated the subject of the features very well." Another judge from a Mississippi state agency wrote: "Although it seems you have very few staff writers, the writing style seems consistent" and "The articles were clear and can be easily understood by this lay person reading them."

The three issues of *Defense AT&L* that were awarded recognition in the NAGC competition included those of January-February 2015, May-June 2015 and November-December 2015 (covers shown above). The winning entry for APEX was the single May-June 2015 issue.

Bringing Metals Into the 21st Century

Joe Steele

From 3D printing and smart textiles to digital and photonic circuit manufacturing, a great deal of creative and innovative work is being done by the various National Network of Manufacturing Innovation (NNMI) institutes and their industry academic and research partners.

But what about a material that people have been using for tools, weapons and transportation for millennia? For centuries, people have been using various metals to form objects or tools they have needed.

What is it about metal manufacturing that is still so innovative in the 21st century? Can the idea of melting, shaping or casting metal be revolutionized to meet our current manufacturing and defense needs while we remain mindful of conserving both resources and energy?

That is the mission of LIFT—Lightweight Innovations for Tomorrow—operated by the American Lightweight Materials Manufacturing Innovation Institute.

Founded in 2014, LIFT is a Detroit-based, public-private partnership committed to developing and deploying advanced lightweight metal manufacturing technologies, and to implementing education and training initiatives to better prepare the metal manufacturing workforce today and in the future.

One of the founding institutes of the NNMI, LIFT is a member-based organization funded in part by the Department of Defense (DoD), with management through the Office of Naval

Steele *is director of communications at LIFT—Lightweight Innovations for Tomorrow—in Detroit. He is a communications professional with expertise in public affairs, community and public relations, as well as traditional and digital communications strategies.*

Can the idea of melting, shaping or casting metal be revolutionized to meet our current manufacturing and defense needs, while we remain mindful of conserving both resources and energy?

Research to develop technologies to benefit the U.S. transportation, aerospace and defense markets.

"Our goals are twofold," says Larry Brown, LIFT's executive director. "The first is to accelerate development and application of innovative lightweight metal production and manufacturing technologies, and the second is to build a robust talent pipeline for the advanced metals manufacturing factories of tomorrow."

In pursuit of these goals, LIFT partners with its members, including large corporations, small and medium enterprises, business startups, professional societies, colleges and universities, and other research institutions, to move lightweighting manufacturing technology concepts to the marketplace.

On education and workforce development, LIFT works with universities, community colleges, kindergarten through grade 12 schools, economic development corporations, workforce intermediaries, manufacturing extension partnerships, industry, and state and local government officials to improve education related to manufacturing and science, technology, engineering and mathematics (STEM) training.

"Our mission is a challenging one," Brown says. "I tell our members that what we are attempting to do is not easy, because we are rethinking an industry that's been around for thousands of years. It is exciting, but it's not easy."

Lightweight metals manufacturing does face challenges, both from a technology perspective, with lightweight metals being more expensive to purchase and process, and on the education and workforce development front, with many misconceptions about manufacturing jobs and careers being low skill, low wage, and vulnerable to offshoring. Despite those challenges, interest on the part of a wide array of stakeholders continues to grow in lightweighting and the research behind it.

Companies are looking to conserve the energy and reduce raw metals used in manufacturing. These significantly include the energy and the transportation sectors such the aircraft industry and automakers. Cars must meet increasingly stringent fuel economy standards while adding more technology.

The LIFT mission is clear, and the partners are in place to develop new methods of lightweight metal manufacturing through improved technology and to create a talent pool of educated workers to support the jobs of the future.

Lightweighting Through Technology

The earliest forms of metallurgy, the science behind metal properties and production, date back to rudimentary tools and weapons created thousands of years ago. While the basics of using metal to create objects in different shapes and sizes have remained consistent, the metals used and processes in place have changed dramatically. "People have been heating, stretching, casting and beating metals for thousands of years," says Alan Taub, LIFT chief technology officer. "But we are at the cusp of a revolution in terms of the way we are able to process and design them in far different ways than ever before."

By focusing on specific process areas, and distinct themes that cut across all of them, LIFT is working with its industry, government, academic and research partners to bring metals to the market in a whole new way.

LIFT's technology focuses on six "pillars," including:

Melt Processing. Casting is just one well-known example of the manufacturing processes involving molten metal. At LIFT, many others are being re-examined and transformed by new technologies and lightweight metals.

Powder Processing. Generally squeezed, sintered and/or sprayed to form parts, sheet or plate, metal powders allow great control over the final composition of the end product and its properties and yield.

Thermo-Mechanical Processing. Advanced metal processing technique using heat and deformation and can be applied to forming operations, including forging, rolling and extrusion.

Coatings. More than just paint, emerging coating processes are modifying the surface of metals to enhance their performance in exciting new ways.

Joining and Assembly. A key challenge for the application of lightweight metals to manufactured goods is joining them to other lightweight metals, traditional steel alloys, or nonmetallic metals.

Agile Processing. The pacing and cost of introducing new light metal components often are determined by the required tools and dies. New technologies, tool-making methods and

advanced machining can eliminate dies entirely and reduce cost and speed of deployment.

The LIFT technology focus also includes themes that cut across each of the technology pillars, including design, life-cycle analysis, validation/certification, cost modeling, supply chain, corrosion, ballistic blast, and integrated computational materials engineering (ICME).

Development of ICME and computer modeling is a game-changer for lightweight metal design and processing. It carries great promise in creating computer "super models" that combine a much wider array of property and processing information than previously possible without the expense of developing, testing and validating property and process relationships.

LIFT partners also have several projects under way—in the melt processing, coatings, joining and thermos-mechanical processing pillar areas, with more on the horizon for 2016.

Earlier this year, nearly 100 LIFT members gathered in Detroit to take part in a 2-day technology road-mapping session to determine the long-term direction of LIFT's technology development, including new projects it might undertake based on the industry's needs and future trends.

Several project teams were launched and are seeing progress with positive results from their work. In fact, preliminary results on one of the first melt processing projects have shown a nearly 40 percent weight reduction in the specific part being cast. "With the knowledge and ideas from our members, there can be no question that our current projects, and those we'll pursue going forward, will result in dramatic changes to the metal and manufacturing industries," Taub says.

Education and Workforce Development

Commercializing innovation—or bringing "mind to market"—is only possible if educated talent is available to put new ideas and technologies to work. That means that the goal of making the United States the world leader in lightweight metals manufacturing requires training a skilled workforce that can develop and manage these new technologies and processes. With that in mind, LIFT is supporting initiatives to provide a competent and confident workforce for the advanced manufacturing jobs of the future.

"Developing a skilled workforce is mission critical to the future of manufacturing here in the U.S.," said Emily Stover DeRocco, LIFT's director of education and workforce development. "Our goals are to eliminate the current skills gap in order to sustain, grow and attract manufacturing jobs across the country, and to prepare a technology-savvy next generation workforce."

To achieve that goal, the LIFT Education and Workforce Development roadmap was developed in coordination with education, workforce development, economic development and labor experts and includes 11 areas of strategic focus:

The goal of making the United States the world leader in lightweight materials manufacturing requires training a skilled workforce that can develop and manage these new technologies and processes.

- Understanding workforce demand-supply gaps
- Ensuring students gain STEM foundational skills for success in manufacturing careers
- Attracting students and workers to educational pathways for careers in manufacturing
- Deploying more on and off ramps from education to employment
- Helping disconnected youth and adults prepare for high-quality, middle skills jobs
- Linking and leveraging related incentives and resources on the ground today
- Teaching the teachers
- Adding lightweighting technologies to engineering design curricula
- Expanding work-and-learn activities
- Fast tracking military personnel and veterans to skills development for manufacturing careers
- Offering on-the-job training solutions to industry partners

Each of LIFT's Education and Workforce Development investments strives to positively impact at least one of those focus areas. Recent examples include delivering machinist training for veterans in Indiana, providing metals science boot camps for teachers in Tennessee, familiarizing Kentucky educators with modern manufacturing workplaces, supporting work-and-learn opportunities in Ohio, and reaching out to disengaged and unemployed youths and adults in Michigan.

Innovating for the Future

LIFT is one of nearly a dozen new manufacturing institutes that coalesce public- and private-sector talent to upgrade production capacities by using more advanced technologies. Most of the institutes are devoted to developing advanced technologies from scratch. LIFT is demonstrating that even something as old as forming, shaping, joining and casting metal can provide a fresh source of innovation for our economy and defense industry when we put our nation's best minds to work.

For more information on LIFT, visit www.lift.technology, follow LIFT on Twitter at @NewsFromLIFT, email communications@lift.technology or call (313) 309-9003.

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NextFlex

Flexible Hybrid Electronics Manufacturing

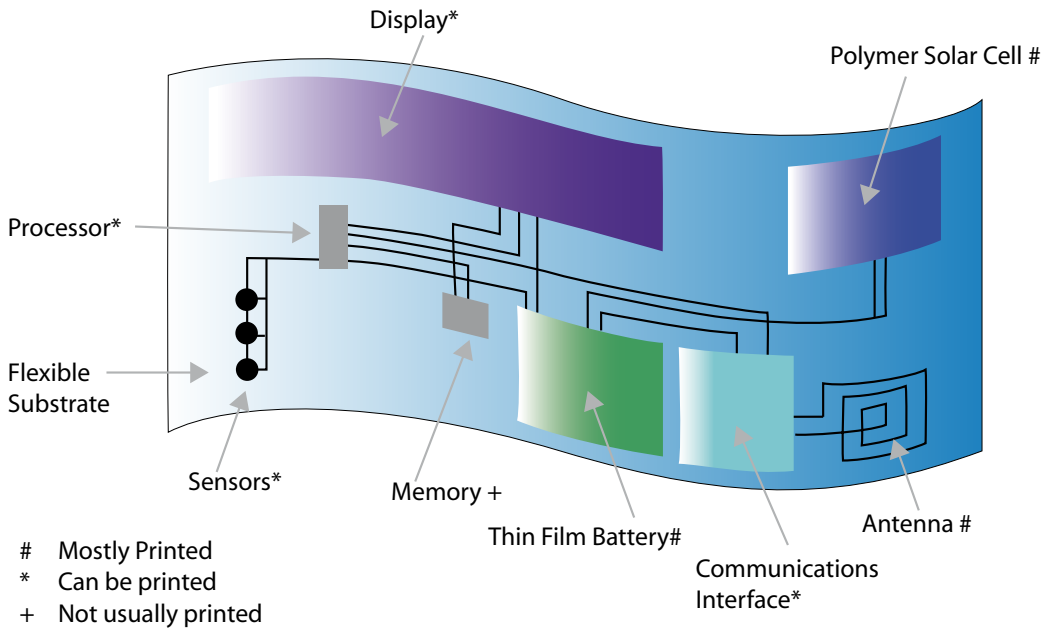
Eric Forsythe, Ph.D. ■ *Benjamin J. Leever, Ph.D.*

NextFlex, America's Flexible Hybrid Electronics Manufacturing Innovation Institute, is a program formed out of a cooperative agreement awarded to the nonprofit FlexTech Alliance on Aug. 28, 2015. NextFlex is the seventh manufacturing innovation institute created to scale up emerging technologies, foster American innovation, and establish a U.S. manufacturing base to accelerate transition into both defense and commercial products. Headquartered in San Jose, California, the "capital of Silicon Valley," the Institute harnesses the region's electronic manufacturing entrepreneurs and innovators, along with a robust U.S. network of manufacturing nodes, to advance a national flexible hybrid electronics (FHE) manufacturing ecosystem. This positions the United States for continued leadership in a critical technology area.

NextFlex is built upon public-private partnerships, and its FHE focus area exists at the intersection of U.S. manufacturing strengths—electronics

Forsythe *is a staff physicist at the Army Research Laboratory in Adelphi, Maryland, and is the Team Leader for Display Technologies and an associate program manager for the Army's Flexible Display Center. Formerly, he was a postdoctoral fellow at the University of Rochester in New York, in both Physics and Chemistry, where he worked on electronic interfaces and carrier transport in organic light-emitting devices in collaboration with the Eastman Kodak Company.* **Leever** *is the government chief technology officer for NextFlex as well as the portfolio lead for Airman Performance Monitoringand Aeromedicine at the Air Force Research Laboratory Materials and Manufacturing Directorate at Wright-Patterson Air Force Base in Ohio.*

Figure 1. Flexible, Hybrid Electronics (Simplified)



Source: FlexTech Alliance

packaging and high-performance printing industries. In February 2016—just 6 months after its award was granted—NextFlex announced 32 Founding Members from these industry segments and academia. To date, the institute has 43 members from across these industry segments, as well as academic partners, with many more in the process of development. Its public-partnership team also includes more than 17 Department of Defense (DoD) and other government agencies across the country that provide technical support to advance FHE technology for their respective missions.

Manufacturing Innovation

FHE is best described as the intersection of additive circuitry, passive devices and sensor systems that may be manufactured using printing methods for flexible substrates—sometimes referred to as printed electronics—with thin, flexible silicon chips or multichip interposers inserted into devices. (See Figure 1 for a simplified view of FHE.) Together, these technologies can take advantage of the power of silicon and the economies and unique capabilities of printed circuitry to form a new class of devices for the Internet of Things (IoT), robotics, communications and medical markets.

While primarily using the term "flexible," the institute covers manufacturing methods that fall into the categories of flexible, stretchable and conformable. The applications are nearly endless—imagine pushing electronics, which are typically housed in rigid, square boxes, into close contact with rounded, flexible parts of the world around us. Consider intelligent bandages, which are placed on a patient's skin and able to monitor vital signs and transmit data to a doctor. Or imagine peel-and-stick sensors that monitor temperature, vibration and other data for critical equipment, reporting location and status through the cloud. Finally, think about high-performance antennas and radios being printed on the wings of aircraft, or large safety sensors being adhered to structures to warn of danger. NextFlex is pursuing methods to scale up today's FHE laboratory experiments into smart, affordable products. FHE manufacturing encompasses innovative electronic packaging processes, such as automated high-speed pick and place, printing processes, and fabrication of sensing elements, with substrate handling and imprinting. These innovative manufacturing processes will integrate thin flexible silicon electronic devices, sensing elements such as biomedical devices, communication devices, and power into novel conformal, flexible and stretchable platforms. FHE will create novel sensor and device form factors through the convergence of traditional electronic packaging and high-precision printing industries that advance high-tech U.S. manufacturing.

Scale up of manufacturing processes to Manufacturing Readiness Level 7 will catalyze these disparate supply chain elements and enable a national ecosystem that creates novel products for the DoD and the larger commercial sectors across health and human monitoring, wearable electronics, and medical devices that interconnect the world around us through the IoT. Electronic Design Automation (EDA) software tool development is a critical focus area for the institute that brings together the printed circuit board (PCB) and integrated circuit (IC) industries with the mechanical design software packages. Suppliers only recently have begun adopting these design tools for new FHE materials sets, form factors, and applications. The software design tools will encompass multiphysics simulation (e.g., electrical, thermal, mechanical, etc., interactions based on first principles physics modeling to optimize device performance) to deliver a complete circuit layout supporting FHE component integration.

The technical manufacturing objectives will provide new abilities to the DoD and commercial products as dramatically reduced electronic systems size and weight lead to systems that can conform to complex shapes such as aircraft wings, unattended vehicle platforms, and human bodies. These advances are creating innovative medical devices that can take

on human-soft robotic interfaces or be implanted or applied. They can monitor health or stimulate physiology for the benefit of many groups, such as warfighters, the elderly, and those with chronic conditions.

The institute technical strategy features nine technical roadmaps (see Figure 2), each developed and maintained by a separate Technical Working Group. Five of these represent Manufacturing Technology Areas (MTA): Device Integration, Materials, Printed Flexible Components and Microfluidics, Modeling and Design, and Test and Reliability. Supplementing these manufacturing topics are four Technology Platform Demonstrators (TPD), representative product platforms used to integrate the technologies proven by the MTAs and representing critical application sectors: Human Monitoring, Asset Monitoring, Integrate Array Antennas, and Soft Robotics. Cross-cutting influences exist between these two groups. Design requirement developed by TDP working groups are fed into the MTA working groups, which then develop a schedule of technical priorities and specifications for project calls. Project results from across all five MTAs are then brought into the definition of TDPs to demonstrate an integrated solution with associated production processes.

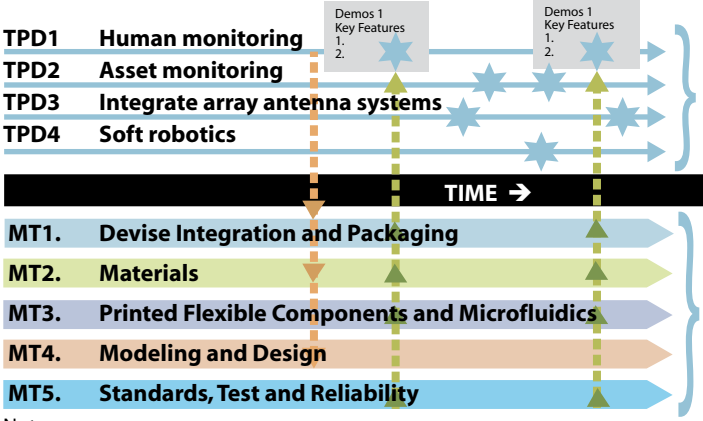
The technical manufacturing objectives will enable DoD and commercial products with dramatically reduced electronic systems package size and weight lead to systems that can conform to complex shapes such as aircraft wings, unattended vehicle platforms, and human bodies.

Accelerated Beginning Due to Previous Consortium Experience

NextFlex membership provides many ways for companies to participate in technical planning and activities—e.g., shaping and maintaining the NextFlex technology roadmap. Members also participate in institute-funded projects, education/workforce development, and institute governance. Other key aspects of membership include access to the Institute hub facility in San Jose and partner nodes throughout the United States, and participation in a friendly intellectual property (IP) policy designed to reward invention and speed commercialization. The tiered structure presents various opportunities to more directly influence the overall direction of the organization, especially at the higher levels.

NextFlex experienced a rapid start to membership and project calls due to previous industry consortium experience. In particular, the FlexTech alliance has a well-established membership agreement and IP policy that has been proven acceptable to both industry and academic institutions. This policy grants IP ownership to the inventor but balances the rights of the inventor with rights of institute members to experiment with

Figure 2. Strategic Roadmapping Framework



Note:
TPD = Technology Platform Demonstrator
MT = Manufacturing Technology
Source: FlexTech Alliance

"What" We Do

- Led by Tech council
- Strong end-user participation
- Demos describe "what" the institute is doing in manufacturing
- Revised annually

"How" We Do It

- Industry led at Working Group level
- Clear boundaries, detailed roadmaps and deliverables feeding into Technology Platform Demonstrators (TPDs)
- Develop "How"—gap analysis
- Drive Project Calls
- Revised semiannually
-

NextFlex workforce development also is conducting a number of other pilot programs across the country that bring together academia and industry to create aligned education and work-based career pathways.

manufacturing advances. The NextFlex IP model allows all members access to IP developed using Institute funding for R&D purposes, but requires payment of licensing fees to the owner for purposes of commercialization. The IP policy also considers issues such as blocking IP, background IP, and reasonable levels for nonexclusive licensing costs. Through previous experience and by seeking feedback from representative members before the award, NextFlex was able to accelerate the development and validation of the membership agreement and ensure that advanced technology developed within the Institute was widely disseminated through the U.S. FHE Industrial base.

The institute is moving very fast and has released two Requests for Proposal (RFPs) in 9 months after their award was announced by Secretary of Defense Ashton Carter. There were 73 proposals received in response to the first RFP that focused on addressing these FHE manufacturing challenges.

Workforce Development

In lockstep with its technological initiatives, NextFlex is laying the groundwork for anticipated FHE talent needs through its workforce development program. Innovative partnerships with organizations such as the BMNT consultant group in Palo Alto, California, and the Defense Innovation Unit experimental (DIUx) in Mountain View, California, focus on a range of activities that include the development and execution of weeklong "sprint" courses in lean startup designs with a focus on DoD problems. Similarly, another workforce development project is the Hacking for Defense course at Stanford University, which trains students and the next generation of personnel to work on challenging DoD problems. During this course, graduate students learn how to apply lean startup principles to DoD problems through the design, development and, in some cases, manufacturing of minimum viable products (MVP) or prototypes to demonstrate the viability of their ideas (see Figure 3).

NextFlex workforce development also is conducting a number of other pilot programs across the country that bring together academia and industry to create aligned education and work-based career pathways at the technician and technologist level to develop and deliver people with the right skills for companies within local and regional FHE ecosystems.

Finally, to help better understand the state of the FHE workforce, the institute is conducting a taxonomy study of the supply and demand aspects of the full talent pipeline across the FHE ecosystem.

By building workforces and by working toward technical manufacturing objectives, NextFlex is cultivating a balanced and thriving manufacturing ecosystem to create the next generation of crucial electronic products for the DoD and commercial segments.

For more information, see the website at http://www.nextflex.us/

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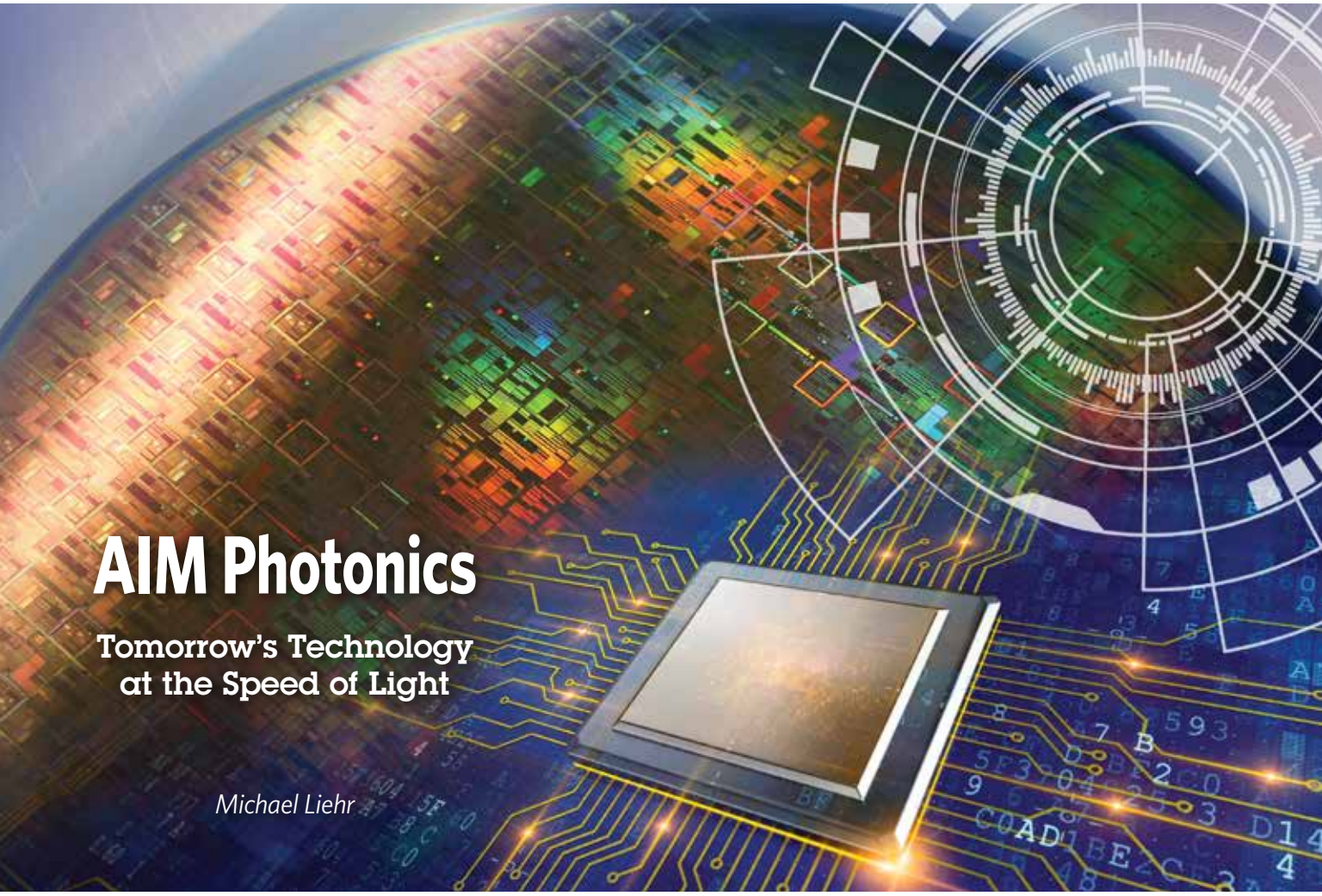
Figure 3. Growing a Lean, Flexible Workforce



AIM Photonics

Tomorrow's Technology at the Speed of Light

Michael Liehr

Over the last 40 years, semiconductor-based electronics have changed the way we work, interact with one another and relax. The shrinking size of transistors—the fundamental building blocks used, e.g., as switches in computers and many other electronic devices—has led to an ever-increasing complexity in the tasks such semiconductor circuits can accomplish. Despite the field's escalating complexity, the associated costs have rapidly decreased over this same time through innovations and scaling in the underlying manufacturing technologies.

The semiconductor industry has enjoyed decades of constantly increasing integration and miniaturization, often referred to as "Moore's Law"—continuation of which requires unrelenting cost reduction. In the process, business models have been developed that substantially contribute to productivity. These include the formation of "fabless" (outsourced fabrication) companies, dedicated foundries, independent electronic design automation companies

Liehr *is the chief executive officer of the American Institute for Manufacturing (AIM) Integrated Photonics, where he focuses on creating new AIM business opportunities and is responsible for the effective and efficient operation of AIM's programs, including the State University of New York (SUNY) Polytechnic Institute's strategic 300-millimeter (mm) integrated photonic semiconductor and 3D packaging. He also is SUNY Polytechnic Institute's vice president for research. Earlier, he led the Global 450mm Consortium through the start-up phase as the general manager and was an IBM Distinguished Engineer.*

The clean room used to manufacture the integrated photonic circuits that the American Institute for Manufacturing (AIM) will be providing future access to through multiproject silicon wafer production runs.
Photos courtesy of the State University of New York Polytechnic Institute.

(companies that offer design libraries and prequalified blocks of intellectual property to circuit/system designers), and equipment and material suppliers. As a result, today's microelectronics landscape is comprised of a large, disaggregated but mutually interdependent fabric of enterprises. Moore's Law enabled the emergence of the Internet, the personal computer and the laptop, as well as the cell phone and myriad other ubiquitous products that have transformed our world.

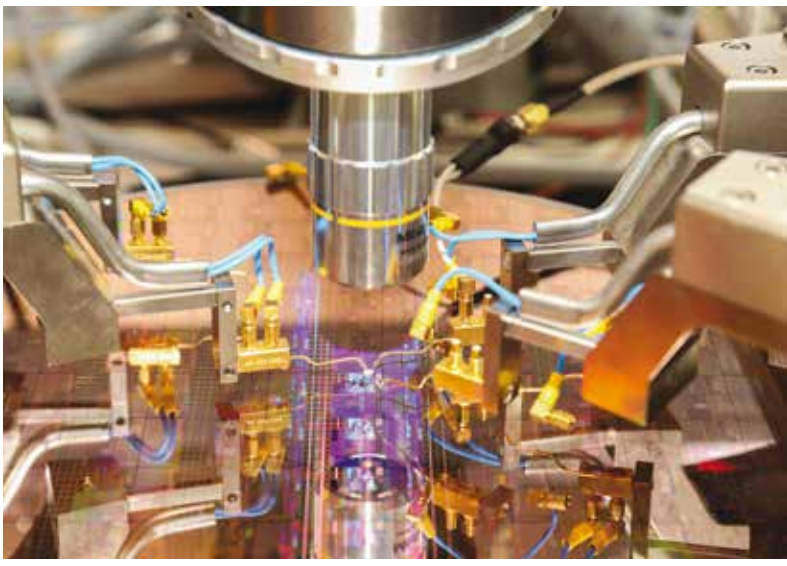
We are expecting the technological limit of scaling to be reached in the near future where any further increase in speed and complexity will increase cost, power consumption and heat too much to allow further, practical miniaturization. Light propagates through optical fibers with much less loss than what is experienced by electrical current passing through wires—a well-known fact exploited by telecommunication companies using optical fiber for more than a quarter-century. The question naturally arose of whether a photonics approach could alleviate any of these issues. To explore this question, scientists and engineers have worked for more than a decade on merging the elements of optical systems with the tools and techniques enabled by the semiconductor revolution.

This emerging field, known as integrated photonics, attempts to replicate the semiconductor business model in the field of photonics (a subfield of optics focusing on the interaction of photons and electronics). To accomplish this, researchers have continued focusing on miniaturizing optical elements by fabricating them using standard wafer-level processing tools. This also simultaneously reduces cost (integrated photonics thus refers to the use of semiconductor processing techniques to realize photonics systems). The remaining assembly steps, such as attaching optical fibers to a packaged part, will necessitate the creation of new, or dramatic redesign of existing, microelectronics assembly tools. Today, packaging and assembly are the most significant cost contributors to manufacturing photonics products.

The implementation and application of integrated photonics already has begun with emerging use in telecommunications and more recently data centers, in which communication between server racks has migrated to fiber transmission. This transition is expected to progress as copper cables of shorter and shorter distances are replaced with optical fibers leveraging integrated photonic circuit based transceivers on their ends. It is also anticipated that integrated photonics will be leveraged by several additional industry segments to address needs in microwave, array and sensor applications.

The impact of photonics over the next 20 years will reach across all spectrums—from defense, space and communications, to driverless vehicles, advanced drone applications and consumer applications. For example, LIDAR (a laser-based implementation of radar used to extract distance information) for automotive, body sensing and holographic user interfaces are all disruptive photonic technologies that should change how people commute, interface and communicate in the near future.

The greatest challenge for all these technologies is taking them from proof of concept to commercialization. This challenge provided the impetus for the creation of the American Institute for Manufacturing of Integrated Photonics: AIM Photonics.



At right , another view of work in the clean room used by AIM. Above, a silicon wafer being examined under magnification.

The Institute's Mission and Vision

Established in 2015, AIM Photonics is a manufacturing innovation institute headquartered in New York. As a Manufacturing Institute funded by the Department of Defense, the mission of AIM Photonics is to enhance the maturity of the U.S. integrated photonics industry by developing and deploying manufacturing technologies. The institute will focus on four primary areas of manufacturing technology that were identified as key hurdles to widespread adoption on integrated photonics:

- Electronic and photonic design automation
- Multi-project wafer processing and packaging
- Inline control and test
- Test, assembly and packaging

The development of these capabilities will promote the maturation of manufacturing around key technologies, thereby enabling rapid photonic development through proof of concept, validation, qualification and commercialization under one national institute, ensuring manufacturing advancements for years to come. In addition, AIM Photonics will support hardware builds via a multi-project-wafer service and offer capacity to meet governmental and industrial needs for early user hardware.

To validate advances made in the manufacturing technologies and to support industrial members, the institute will develop and demonstrate innovative manufacturing technologies for:

- Ultra-high-speed transmission and switching of signals for the Internet, telecommunications and datacenters
- Integrated microwave photonic circuits (using light to transmit and process optical signals encoded with analog information at frequencies in the gigahertz regime)
- Sensor applications including chemical and biological sensors, navigation sensors and other sensor types/topics
- Applications requiring the formation of arrays of components (e.g., the LIDAR application noted above)

As it develops these technologies, AIM Photonics will maintain a focus on providing state-of-the-art capabilities by integrating traditional photonic technologies with advanced nanotechnology transistors on a silicon wafer fabricated using a standard silicon foundry process. This effort will decrease cost, reduce the time to market, and alleviate market entrance challenges for all members of the photonics community.

AIM Photonics is supported by a significant number of large, medium and small companies, as well as several states, notably New York, California, Massachusetts and Arizona. The state of New York, in particular, has committed substantial financial resources to build new manufacturing research and development capabilities to support this Institute. These funds also will be used to improve upon existing state-of-the-art infrastructure and capabilities within the state of New York. At its technical headquarters in Albany, New York, AIM Photonics boasts a fully integrated 300-millimeter silicon wafer capability that has been used extensively to support prior government and industry projects in integrated photonics. In addition to

the Albany facility, enhancements to enable broader access to processing capabilities for small and medium enterprises, AIM Photonics also has planned, and has now entered, the execution phase of an integrated photonics test, assembly and packaging facility in Rochester, New York. These two facilities will provide the backbone of the institute's capabilities, but satellite facilities at its partner locations in Santa Barbara, California, Tucson, Arizona, New York City, and Boston, Massachusetts, will add to this network additional key skills and capabilities critical to the Institute's long-term success. Photos of a silicon wafer containing electrical circuits and attached optical die and the 300mm cleanroom in Albany in which the wafer was built are shown on Pages 36 and 37.

Integrated photonics is being developed on indium phosphate- and silicon-based platforms, both of which will be available through the AIM Photonics Manufacturing Innovation Institute. Silicon photonics in particular has the potential to significantly reduce the cost of optical devices used in many traditional systems in addition to enabling new devices and applications. The availability of a state-of-the-art complimentary metal-oxide-semiconductor (CMOS) processing facility and infrastructure in AIM Photonics will allow efficient photonic integration. In addition, the ability to integrate photonic devices with CMOS electronics in a wafer-scale manner can greatly increase the capacity of integrated circuits and reduce the size, weight and power dissipation while simultaneously increasing the reliability of the systems employing these components. AIM Photonics also provides a variety of solutions for integrating the critical functionality of III-V materials, ranging from monolithic indium phosphide photonic integrated circuits to heterogeneous materials integration.

The AIM vision is to establish a domestic technology, business and education framework for industry, government and academia to accelerate the transition of integrated photonic solutions from innovation to manufacturing-ready deployment in systems spanning commercial and defense applications. The application spaces expected to be the first in which there is widespread commercial adoption are: high-speed digital photonics for data centers; high-speed analog photonic links for analog data remoting applications; and photonic sensors for the developing Internet of Things.

Launch of the Institute

During its first 9 months, AIM Photonics established a series of business processes for the roadmap-based development, submission, down-selection, and funding of projects of interest to its stakeholders. Within the initial 4 months, AIM Photonics completed the first cycle of project selection and awards. Out of almost 50 project proposals submitted, our team of experts selected those that fit the goals of AIM Photonics and were compatible with the initial capabilities of our facilities. AIM Photonics now is entering its second annual cycle of project awards with a call for proposals having been announced in April.

Additionally, AIM has merged an integrated photonics roadmapping effort (sponsored by the National Institute of Standards and Technology) into its portfolio of projects and has launched an ambitious nationwide effort in education and workforce development. This effort, titled the AIM Academy, will ensure that AIM Photonics provides the manufacturing readiness to build integrated photonics, and develops the requisite workforce to support such an integrated photonics ecosystem. AIM Photonics intends to provide the domestic industry with critically important skills ranging from technician and manufacturing-line operator to Ph.D.-level skills in design, test and process development with key instructional resources from notable universities such as the Massachusetts Institute of Technology, Columbia University, the University of Rochester, the University of California, Santa Barbara, and others. In parallel with the development of courses with stackable credentials across the range of educational needs, AIM Photonics also has embarked on a detailed industry study to identify which skills are required in which geographic region in order to best match needs to available skills.

A Truly Innovative Institute

The unique combination of education, training and technological innovation that AIM Photonics provides will help speed the domestic integrated photonics manufacturing industry into the future. With innovation around the manufacturing of integrated photonics, new technologies are being developed that will conserve energy in the manufacturing process and allow for unprecedented advances in novel applications.

Contact us at www.aimphotonics.com,
https://aimphotonics.academy,
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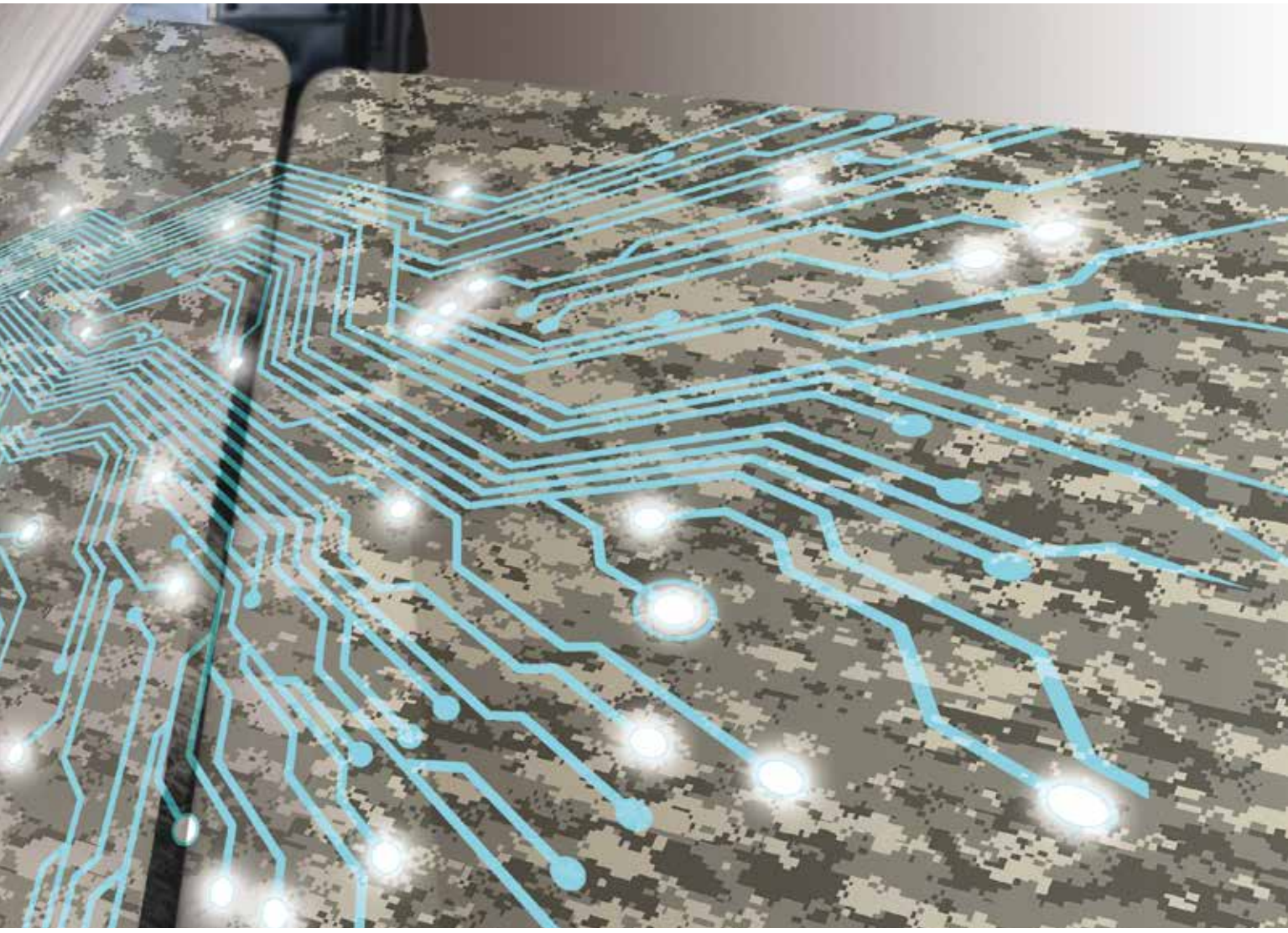
A Fabric Revolution

AFFOA Is Weaving the Next Fiber and Textile Revolution

Stephen Luckowski ■ Deborah Kahan
Abhai Kumar

Our clothes help define us, yet the fabrics we wear have remained virtually unchanged in many respects for thousands of years. Recent breakthroughs in fiber materials and manufacturing processes soon will allow us to design and manufacture fabrics that see, hear, sense, communicate, store and convert energy, regulate temperature, monitor health and change color—heralding the dawn of a "fabric revolution."

Luckowski *is a competency manager at the Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey. His primary roles are government program manager for the Department of Defense (DoD) Advanced Functional Fabrics of America (AFFOA) and providing organizational strategic planning for the Materials, Manufacturing and Prototype Technology Division, U.S. Army ARDEC.* **Kahan** *is co-founder and vice president of Thingee Corporation in Parsippany, New Jersey. Her background includes 30 years of experience in strategic/marketing planning and business development for technology companies. For the last 10 years, she has supported prototype manufacturing and technology innovation programs for the government.* **Kumar** *is an engineering and business professional with a keen sense of curiosity, research, development and analysis. His background helps him appreciate a holistic view of issues which help define optimum solutions. He has been involved with most of the DoD-led Manufacturing Innovation Institutes.*



After a decline in U.S. manufacturing during the 2000s, the American textile industry is adding jobs for the first time in 2 decades, increasing shipments by 14 percent from 2009 to 2015, and winning globally with a 39 percent increase in exports from 2009 to 2015. Across the country, U.S. manufacturing as a whole has added almost 900,000 jobs since turning the corner in February 2010.

To take advantage of this textile industry upsurge, a consortium of universities and manufacturers, in conjunction with the Department of Defense (DoD), launched a manufacturing innovation institute that plans to lay the foundation for future leadership in producing sophisticated fibers and textile technologies. Headquartered at MIT in Cambridge, Massachusetts, the Advanced Functional Fabrics of America (AFFOA) is the eighth institute established as a part of the National Network for Manufacturing Innovation (NNMI) program intended to help restore U.S. manufacturing leadership. AFFOA combines $75 million of federal resources with $240 million of nonfederal investment to overhaul American fibers and textiles manufacturing and foster technological innovation in futuristic fabrics and textiles. These will include super-durable, super-lightweight, flame-resistant, and electronic-sensor capabilities that can save the lives of civilians and soldiers alike, and help accelerate the revival of textile manufacturing in the United States.

AFFOA is the nonprofit organization stood up by MIT and unites 89 partner companies, nonprofits, independent research organizations, universities and startup incubators in an effort to ensure that America stays at the leading edge of fiber science and the production of fibers and fabrics incorporating advanced properties.

AFFOA is a public-private partnership intended to generate innovation that will benefit defense and commercial needs. However, the institute will focus

on technologies that have commercial viability since defense requirements often are insufficient by themselves to underpin the development, growth and sustainment of emerging industries to produce leading-edge defense systems. The DoD needs a vibrant, domestic commercial base and these public-private manufacturing research partnerships will contribute to that capability. As a result, the institute will address gaps in textile and fiber manufacturing technology that are common to both commercial and defense applications.

Operationally, the DoD's overarching role is to help establish the institute through federal funding cost share and to partner in providing oversight and stewardship. The DoD's military and civilian agency representatives also will contribute ongoing technical advice and assistance. The institute will have an independent governing council predominantly composed of industry representatives.

AFFOA will bring together fiber and textile manufacturers, system integrators and product companies to transform traditional fibers, yarns and textiles into highly sophisticated, integrated and networked devices and systems. To pursue this mission, the institute will establish a nationwide network that addresses the spectrum of manufacturing challenges associated with multi-component, functional fibers and technical textiles—from design to end products through deliberate plans, projects, and programs. AFFOA also will develop and scale critical manufacturing processes for revolutionary fibers and textiles and mature them to Manufacturing Readiness Level (MRL)-4 to MRL-7. The institute also will provide guidance and serve as a transition partner to accelerate lower MRL activities.

AFFOA will provide aggressive technology transfer, prototyping and pilot production facilities throughout the Fiber Innovation Network (FIN). The institute will rapidly and flexibly produce end-item prototypes through this unique FIN collaborative infrastructure and a suite of computational design tools that are a focus of development. The technology strategy is to combine fibers and yarns with integrated circuits, LEDs, solar cells, and other capabilities to create textiles and fabrics for a variety of industries, such as apparel, automotive, medical, defense, and sports and leisure.

AFFOA also will help commercialize breakthrough innovations in the labs of leading member universities and others, while partnering with local workforce organizations to train workers on how to manufacture these technologies in the United States. AFFOA will support a cross-disciplinary, skills-based workforce and education plan and dedicated start-up incubators, driving innovations for the entire U.S. industry. The institute's headquarters will host a unique prototype facility designed to help start-ups test their first products and scale up new technologies into full production, helping ensure that textile technologies invented in America are manufactured in America.

The institute's scope will encompass novel commercial and DoD products such as:

- Shelters with power generation capability and storage capacity built into the fabric
- Ultra-hydrophobic, insulated tents that keep hikers and soldiers dry under extreme weather conditions
- "Smart" soldier uniforms enabled with friend/foe identification that allow for power and data transmission through the fabric
- Textiles that sense chemical/biological/radiological/nuclear agents, provide sound reduction, and enable solar generation of power from the fabric itself
- Apparel capable of changing color, based upon environmental conditions or wearer needs, monitoring health factors to both sense and treat injury, generating and/or storing energy from the wearer's activity, and auto-regulating the wearer's body temperature
- Thermal insulation with low bulk that is lightweight, comfortable and able to adapt to both hot and cold environments
- Home insulation and road construction materials that can monitor the performance of insulation and water permeability to react to varying environmental conditions

Since all of the Manufacturing Innovation Institutes were created to bridge the gap between basic research and development (R&D) and its products, and to create a sustainable, domestic manufacturing ecosystem, a Technology Investment Agreement (TIA) was selected as the most appropriate contract instrument. A TIA enables work on applied and advanced research projects that are relevant to the policy objective of civil-military integration and the creation of a single, national technology and industrial base to support national defense needs.

The basic idea behind a TIA is flexibility. TIAs allow the DoD to contract with firms that will not, or cannot, participate in government cost-reimbursement R&D Federal Acquisition Regulation contracts or standard federal assistance awards. These contractors might be small, startup technology firms supported by venture capital, leading-edge technology firms that haven't worked on a government R&D contract, or industry giants that have chosen not to operate in the government market. The contract with AFFOA is administered through the Army Contracting Command-New Jersey (ACC-NJ) and provides for 5 years of operation and a 6-month standup phase.

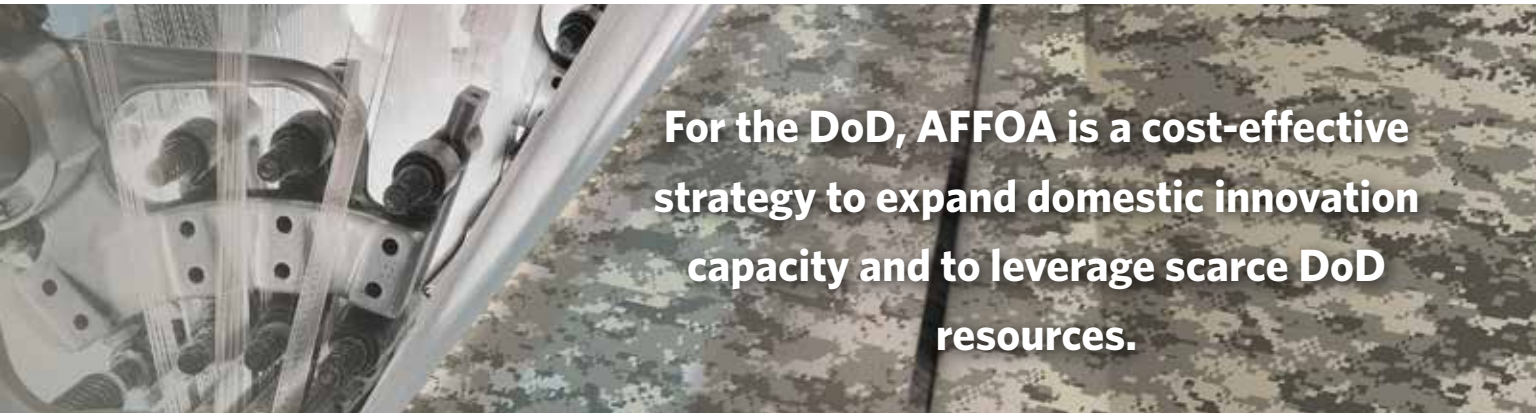
AFFOA's near-tem priority is to stand up its operations. The leadership team will work to finalize agreements with member companies, and universities, establish operations within the headquarters, and develop a roadmap to guide technical project development. The exact natures of the projects to be executed have yet to be defined, though the proposal included three sample projects, one of which focuses on Data Management, Modeling and Analytics throughout the Textile Supply Chain. The government and AFFOA see this as a foundational project for the institute, as it will provide the community with design tools needed by textile end-users to deploy new manufacturing technologies. It is expected that this will be one of the first projects executed within the institute.

AFFOA also will provide significant educational opportunities to improve and expand the manufacturing workforce, including kindergarten through 12th-grade programs, internship opportunities, skills certification, community college engagement, university collaboration, graduate studies, postdoctoral studies, and retraining to meet the requirements of the institute's mission.

AFFOA: Weaving Together Commerce and Defense

The DoD has a history of investing in forward-looking technologies to give the warfighter advantages on the battlefield. AFFOA, like the other Manufacturing Innovation Institutes, represents a broad strategic partnership with academia and industry to allow new science and technology to generate commercially viable applications that will have dual use applications, civilian and military. For example, in textile manufacturing, electronic textiles that enhance warfighter health monitoring also could support the collection of patient medical data in hospitals. The DoD's intimate involvement in the planning and oversight of AFFOA ensures that defense and battlefield applications will be built into the R&D process from the outset. For the DoD, AFFOA is a cost-effective strategy to expand domestic innovation capacity and to leverage scarce DoD resources.

AFFOA also will help stitch DoD and the textile industry more tightly together. DoD prefers that a domestic supply chain manufacture its products, but many commercial companies are vulnerable to ebbs and flows in the defense demand cycle. In past years, some have moved their operations overseas, weakening the U.S. supply chain. Manufacturing Innovation Institutes, such as AFFOA, provide an opportunity for the government to invest in new manufacturing technologies that will enhance both defense and commercial products and reestablish shared and balanced manufacturing capability that allows companies to bring more and better textile jobs home. For industry and government alike, AFFOA creates a stronger fabric of support.



For more information, see the website at http://join.affoa.org/

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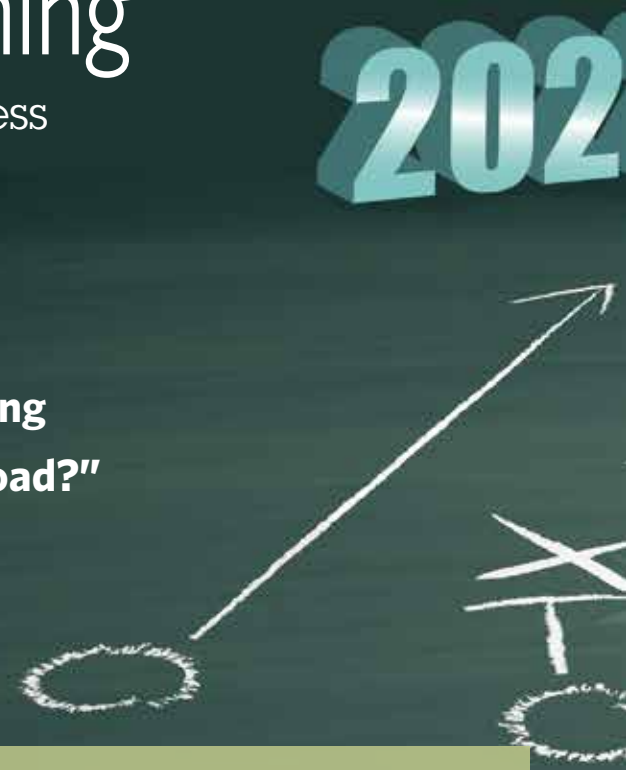
Strategic Planning

Shaping Future Success

Brian Schultz



"What's the use of running if you are not on the right road?"

—German proverb

Department of Defense (DoD) program managers (PMs) typically face significant challenges in executing their current program as reflected in their acquisition program baseline. While the current program may have several years of cycle time prior to delivery and fielding, the PM may also be planning for future increments, sustainment and other long-term efforts. Strategic planning can help the PM position these future programs and actions for good outcomes.

So what is this strategic planning all about? Let's start with some background, including a strategic planning definition from Wikipedia:

> Strategic planning is an organization's process of defining its strategy, or direction, and making decisions on allocating its resources to pursue this strategy.

The origins of strategic planning can be traced to early military leaders like Sun Tzu who lived several centuries ago. His "Art of War" is still read today in military studies as his philosophy has proved to be enduring even as warfare has evolved significantly. Businesses use strategy to determine everything from corporate direction, competitive positioning, investments in research and development, acquisitions and divestitures, marketing and sales campaigns

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and other activities that support the overall strategic plan. Business strategy can make or break the future of a company—therefore, it involves top management.

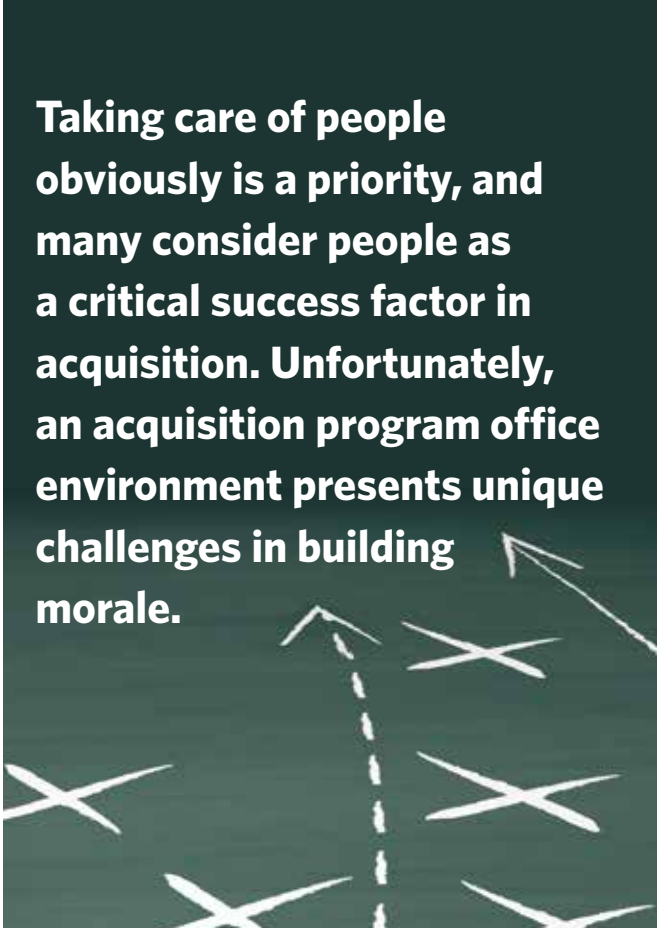
Strategic planning became very important for companies during the 1960s and remains an important aspect of overall corporate strategic management. Companies must plan their strategies and ensure alignment of resources and plans in order to support the strategies, usually over 3 to 6 years. Given the current environment of rapid change and new technology, companies also need to monitor their strategies and be prepared to change course if business conditions change or execution does not meet expectations.

In the 1960s, Defense Secretary Robert S. McNamara (a former Ford Motor Corp. president) introduced the Planning, Programming, and Budgeting System (PPBS) to the DoD. Prior to that, the DoD's budgeting focused on areas such as overhead, salaries and investments, not on the strategic objectives desired from the resource allocations. In the federal government, formal strategic planning was mandated with passage of the Government Performance Results Act (GPRA) of 1993. GPRA requires agencies to develop strategic plans, performance plans and conduct gap analyses of projects. Federal agencies also are required to conduct performance management tasks such as setting objectives, measuring results against the objectives, and reporting progress against the overall strategic plan.

In looking at how strategic planning can help in acquisition, it can be helpful to examine how industry uses it since companies starting using this process in the 1960s to help determine competitive strategies, research and development, and other investment and corporate actions to grow a company's sales.

Strategic Planning

There are many variations and approaches to the strategic planning process, but they all should start with the desired end state. This end state often is called the vision or future end state and represents what the organization is attempting to achieve. It is important to establish a compelling vision that clearly articulates what the future end state should look like. This compelling vision statement will be shared with not only within the organization, but often with other stakeholders as well and sets the stage for everything that follows. The vision communicates the direction of the organization and should be easily understood and concise.



Given the long-term mission of many program offices, a vision will help ensure that staff members understand what the team is trying to achieve. It gives them the big picture. A vision should not be confused with a mission statement. The mission is what the organization does in order to meet its responsibilities on a day-to-day basis. For a program office, the mission could be as simple as "credible execution of acquisition programs."

As the next logical step, we must define what is needed to achieve the vision. This step involves setting objectives that directly link to the final end state. Finally, action plans must be developed to accomplish the objectives. In order to ensure we are on track, quantifiable goals that can be accurately measured should be established.

PMs should already be conducting strategic planning for the long-term sustainment of their system. Maintenance planning, source of repair, and performance-based logistics may take several years to plan, design and implement. In this case, the guidance is clear and the program office should understand the objectives and metrics needed to monitor the progress toward achieving the vision of the desired sustainment plan.

The following are a couple of good examples of other long-term efforts that are suitable for strategic planning. We learned that adjustments along the way always were needed and that observing interim results was important to build some momentum and to show the team that its hard work was starting to pay dividends.

International Cooperation and Collaboration

I worked in a program office that had a lot of foreign military sales customers but very few cooperative development programs. While representatives of the nations would meet periodically to discuss future efforts, very little was accomplished and frustration set in at all levels. One senior leader called the previous set of meetings a traveling cocktail party. The partner countries agreed that we should pursue more cooperation and collaboration with clear expectations of results.

Our team laid out a strategic plan to achieve the goals, knowing that it could take years to make it happen since it involved getting agreement to some new multilateral international agreements between the partners. We also laid out a progressive order of tactical and strategic meetings to review candidate programs, synchronize requirements, assess funding and determine appropriate acquisition plans.

After more than 4 years of work, we achieved the first cooperative program. We also achieved more effective collaboration between the partners and this assisted not only the acquisition teams but also helped the operational community plan for and obtain new capabilities at reduced cost. One lesson learned was that, without a structure and process to facilitate cooperative and collaborative programs, very little occurred during the previous model except for a lot of information exchanges with little follow-up or focus. Strategic planning helped solve this problem.

From Sole Source to Competition

Some PMs deal with the challenge of breaking out of a sole-source environment. The lack of data rights, loss of critical suppliers, a closed technical architecture, a legacy weapon system with proprietary design, and many other factors can lead to this undesirable situation.

Migrating to a competitive environment can take years and can be a good objective for strategic planning. For example, I worked a program that was stuck in a sole-source situation for decades. We developed a long-range plan that involved several actions. First, we communicated the objective to our team and to industry. We also made it clear that we would work this initiative over a period of years but also solicited their feedback. Second, we started planning for open system features in future modifications and developed an intellectual property strategy for obtaining the data rights necessary for some initial competitions (initially at a subsystem level). Finally, we started to migrate the overall technical architecture to a more open model. All of this took time but would not have happened without the strategic planning effort.

Improving the Work Environment

Taking care of people obviously is a priority, and many consider people as a critical success factor in acquisition. Unfortunately, an acquisition program office environment presents unique challenges in building morale. First of all, it can take years to see the results or impact of all the hard work. Second, the

stress level often is high as demands to meet deadlines and recover from test failures and other setbacks are commonplace.

Improving the work environment can take many forms, but here are a few examples based on my experience. First and foremost, ensure that critical vacancies are filled as a priority and in a timely manner. This will prevent staff from having to do "double duty" or pick up more work on top of their already full job jar of responsibilities. It also enables a smoother transition for the newcomer, avoiding the impact of rethinking roles and responsibilities that were temporarily used during the absence.

Providing opportunity for professional growth and development is high on my list of must dos. We used a practice in one program of setting the expectation that staff would periodically rotate into new jobs. This enabled individuals to take on a variety of challenges that might expose them to different facets of acquisition and prevented burn-out from doing the same job for so long. Some of them asked, "Why do we need to move if we are doing a good job and desire to stay in the same job?"

While we did allow some exceptions, the typical response to resistance was that you were holding someone else back from that great opportunity you were provided. We also ensured that individuals and their supervisors stayed on top of education, training and other development opportunities. This program office became a place where people wanted to work, and turnover was very low. Strategic planning allowed us to envision a program office that was a great place to work and we implemented actions to make it happen. Changing the culture in an organization is not usually a quick process and should not be attempted as a short-term remedy.

More Effective, Quality Manufacturing

Early in my career, I was involved in a program that fielded a great warfighting capability, but the system was plagued with reliability and maintainability issues. It turned out that manufacturing process issues were a big part of the quality and reliability root cause. It got to the point where the user asked us to stop fielding this system until the supportability situation improved. The program office stopped production until improved processes and materials were developed and thoroughly tested. Knowing that we also had future variants of this system on the long-term planning horizon, we used strategic planning to articulate an end state of high quality, manufacturing excellence, and effective sustainment. Working closely with the companies involved, we were able to overcome this initial disaster and eventually fielded systems with high user satisfaction.

In today's rapidly changing environment, technology in manufacturing makes strategic planning especially important. Advanced manufacturing techniques, new materials, increased automation and robotics, and additive manufacturing present opportunities for new production capabilities.

Transforming a Business Model

While a business model often is associated with industry (how it delivers goods and services to make a profit), it can also relate to the DoD. Defense business systems cost billions to operate and maintain and efforts are under way to modernize and transform some of these systems and make them more like commercial ones. In acquisition, some program offices have used efforts such as business process re-engineering and lean to streamline internal operations and find efficiencies in an effort to reduce cycle time. In one large program office, we examined how we developed and reviewed some of the Request for Proposal (RFP) documentation. We learned that some processes could be conducted concurrently rather than serially and that there was some redundancy that could be removed.

I worked in another program office that developed an innovative strategy to implement an online ordering contract for communications, navigation and surveillance (CNS) systems. The idea was that customers could find the equipment they needed and use the contract if they had the funding and need. The contract was used by diverse DoD customers, reducing workload for small, unique orders and providing users a one-stop shop to support many different aircraft upgrade efforts. Once all the necessary documentation was received, the contract could be awarded within 2 weeks, reducing cycle time and ensuring competitive pricing.

Final Thoughts

Strategic planning should be a top priority for any organization's leadership. While we often get caught up in tactical execution issues, PMs and acquisition leaders can influence future outcomes with effective strategies. The vision and strategy though must be continually assessed and monitored to ensure that actions to get there are achieving the interim results. It is not easy, but all the hard work can pay big dividends!

The author can be contacted at **brian.schultz@dau.mil.**

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SURVEY

Holistic Contract Administration

in Army Forces Abroad

MAJ Tina L. Ramirez, USA
Donald P. Gatewood
SSG Eric L. Kirkpatrick, USA
SSG Krishna K. Menon. USA

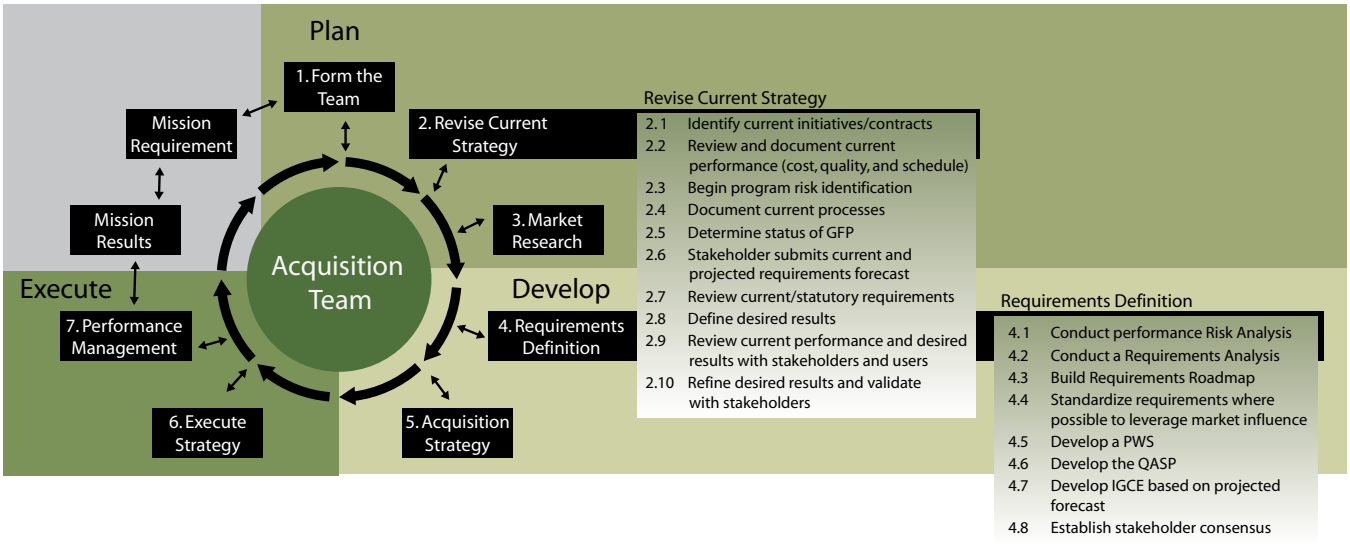
The U.S. Army's Expeditionary Contracting Command (ECC) Contingency Contract Administration Services (CCAS) mission in Kuwait and Qatar has demonstrated that many of the resources required to successfully administer service contracts in a contingency environment already existed within the command but were in need of a little "polishing" and realignment. Given the high stakes of the CCAS Mission, the Battalion set out to establish a solid foundation for effective contract management, thereby reducing risk to soldiers, the mission and funds.

The 926th Contracting Battalion (CBN) was deployed to the U.S. Central Command Area of Responsibility in November 2014 to augment the 408th Contracting Support Brigade (CSB) as the 408th CSB assumed responsibility for the Army CCAS mission from the Defense Contract Management Agency (DCMA) on behalf of Army Contracting Command (ACC). It was tasked to conduct CCAS for contracts executed by ACC-Rock Island Contracting

Ramirez *was the team leader and an administrative contracting officer for the 742nd U.S. Army Contracting Team at Camp As Sayliyah in Qatar.* **Gatewood**, *a U.S. Government civilian employee, was the lead quality assurance specialist for the 742nd Contracting Team, Camp As Sayliyah.* **Kirkpatrick** *was the noncommissioned officer in charge (NCOIC) and quality assurance specialist of the 671st Contracting Team at Camp Arifijan in Kuwait.* **Menon** *was the NCOIC of the 926th Contracting Battalion's Combat Trafficking in Persons (CTIP) inspection team at Camp Arifijan.*

Figure 1. The Acquisition Process

Graphic by author Ramirez, based on the March 2012 *DoD Guidebook for Acquisition of Services*.



Center (ACC-RI) based in Rock Island, Illinois. An overall lack of post-award contract administrative experience presented the 926th CBN with a steep learning curve when it hit the ground in Kuwait and Qatar, but the battalion's soldiers and civilians were able to adapt quickly and discover a number of best practices for successful contract management—and, in doing so, they developed an entirely new perspective on the Army acquisition process as a whole.

Organizational Structure

The 926th CBN deployment was one of the first modular deployments executed by ECC. The modular structure, in which contracting teams of 51C Acquisition soldiers drawn from several different contracting centers were combined with a battalion headquarters, had a number of distinct advantages over the system of individual augmentee deployments that previously was common practice within ACC. The battalion headquarters and individual teams came to the mission with professional relationships and administrative processes already established. With much of the "forming, storming and norming" phases of the team-building process largely completed by the time they were ready to deploy, the teams were able to hit the ground running and move directly into the "performing" phase.

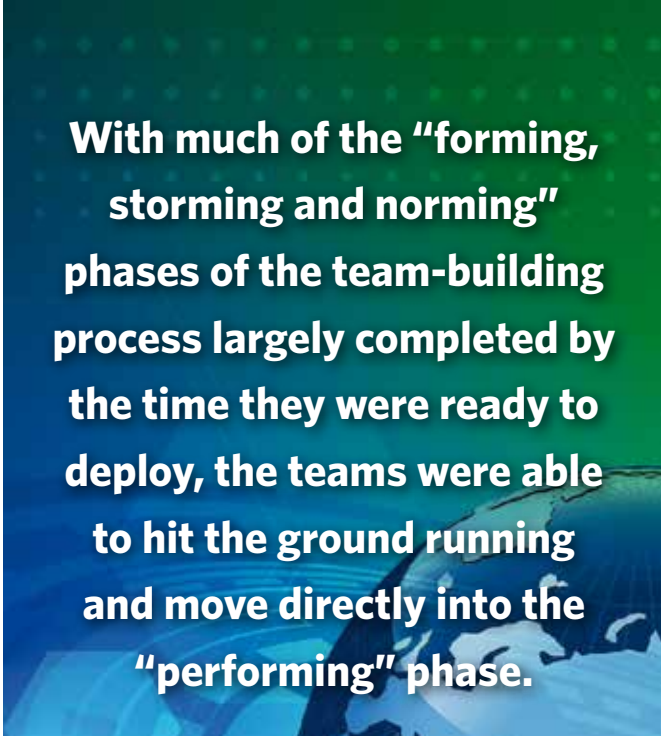
The battalion's 51C soldiers, who had a wealth of pre-award contracting experience but lacked quality assurance and property administration experience, were augmented by personnel within ACC, including 920A or property accounting warrant officers, 92Y or supply specialist noncommissioned officers (NCOs), and Department of Defense (DoD) civilian personnel—i.e., 1910 Quality Assurance Specialist, 1102 Contract Specialist, and 1103 Industrial Property Management Specialist. All of these brought much-needed skillsets to the mission. The 51C NCOs proved their versatility and adaptability by performing as quality assurance specialists alongside their 1910 civilian counterparts, while 51C officers received training and mentorship on administrative contracting officer duties from seasoned DCMA and Army 1102s. The battalion staff task organized itself based on mission support by creating five sections led by a battalion commander and senior enlisted advisor (SEA): These sections were Data Collection and Analysis, Contracting Officer Representatives (CORs), Management, Combatting Trafficking in Persons (CTIP) Team, Property and Operations.

Best Practices for Administration of Services Contracts

Balanced Contract Administration Team

Once on the ground, the 926th was able to leverage its soldiers' diversity of experience from a variety of branches and military occupational specialties. Many of the soldiers in the battalion previously served in military career fields such as logistics, transportation, and maintenance, which provided operational experience that allowed them not only to better understand their supported organizations' contract requirements but also gave them unique insight into their customers' needs and priorities. The natural rapport that developed between the CCAS teams and their customers because of their shared background and organizational culture facilitated trust and communication between them. This positive relationship allowed the Administrative Contracting Officer (ACO), Quality Assurance Specialist (QAS), and CORs to work closely together in a "hands on" approach to contract administration, coordinating their efforts to provide effective contract oversight and present an accurate picture of contractor performance to the procuring contracting office.

Lesson Learned. To meet Army requirements, creating a contract administration team comprised of personnel possessing both operational Army and contracting experience will allow for stronger contract oversight. We must not be afraid to give



up a little contracting experience for invaluable Army operational experience.

Synergizing the Acquisition Team

A Multi-Functional Integrated Process Team (MFIPT) consists of the requiring activity, resource manager, legal advisor, contract execution team, contract administration team, and others. The diversity of roles and geographical dispersion, within the acquisition team, presented significant challenges to synchronizing team members' activities. As the "boots on ground," the CCAS team was a natural fit to take lead in coordinating and aligning the activities of the acquisition team.

Prior to deployment, 926th CBN personnel established professional relationships with the procuring contract officers (PCOs) and contract specialists at ACC-RI by conducting face-to-face desk-side training at Rock Island Arsenal. During the deployment, in-person interaction between the CCAS team and customer organizations created similar working relationships that would have been difficult to duplicate without face-to-face interaction. The customer organizations whose leaders visited ACC-RI PCOs in person or who otherwise remained regularly engaged with the PCOs were, generally, better able to set their acquisition priorities in a more accurate light, thereby allowing the contracting team to align its priorities with those of the customer. In organizations whose mission footprints encompass a great deal of contractor activity, leadership that is not regularly engaged with the acquisition team often gives contract requirements a lower priority, and the organization may pay a price for the leader's lack of awareness. For example, the slow approval and late submission of requirements packets can cause the unnecessary expenditure of millions of additional dollars to pay for unnegotiated extensions and bridge contracts.

Lesson Learned. The CCAS team's efforts toward building and synergizing the MFIPT paid dividends by pulling all team members into one common operating picture (COP) and engaging the leadership of the supported organizations. This allowed the acquisition team to do everything from providing more effective COR management to ensuring that critical acquisition milestones for new requirements were met.

CCAS Team Early Engagement in Acquisition

With the acquisition team members usually operating separately during the acquisition process, the contract administration team for services typically did not engage in the process until the execution phase. With this approach, post-award members were not heavily involved in writing performance work statements (PWSs), performance requirements summaries (PRSs), or quality assurance surveillance plans (QASPs), all of which are critical to achieving results through strong performance management.

Working with the contract execution team based in Rock Island and the requiring activities in-country, the 926th CBN was able to bring real-time contracting, quality assurance and property administration knowledge that it gained from the CCAS mission to the requirements development and planning phases of the acquisition process. This drastically decreased rework by allowing the team to produce consistently better products based on recent lessons learned. Once the requirement entered into the contract administration phase, the post-award team did not have to revamp ambiguous contract documents that lacked critical performance requirements.

Lessons Learned. With all team members reviewing and assisting the requiring activity to develop a strong acquisition packet, documents crucial to successful pre- and post-award were synchronized. This resulted in a better product, written to support strong contract oversight, in less time.

COR Buy-In

The 926th quickly learned that the best way to promote excellent contractor performance and document deficiencies was through strong COR oversight. The teams noticed that, all too often, CORs viewed their contract oversight duties as a lower priority than their "regular" jobs. By empowering CORs with quality training, access to key documents, and regular contact with colocated Army contracting professionals, the 926th witnessed a marked transformation through achieving COR buy-in to the acquisition process. Once CORs realized that the mission accomplishment and risk mitigation depended on effective contract oversight, they became much more active and confident.

Lesson Learned. Properly trained CORs who are given easy access to all the resources they need to perform their duties usually will buy into the acquisition teams and realize the importance of their missions. However, CORs sometimes lack motivation to perform their duties when doing so will not be reflected in their evaluations. Generally, the amount of effort

that a COR will exert in performing contract oversight duty is related directly to the emphasis given those duties in their performance evaluations (known by the abbreviations OERs, NCOERs, TAPES). The CCAS team should take advantage of opportunities to engage customer organizations' leadership in order to emphasize the importance of the COR's role in effective contract administration.

Widening the Window for Contract Administration

Better Buying Power 3.0 lists strengthening of contract management outside the normal acquisition chain through improvements using standard processes, appropriate training and appropriate oversight.

Although it was important for the contracting teams to establish the limits of their contract administrative duties, it was just as important for them to know the organizations and contracts surrounding them so they could see the big picture. Additionally, with contracts that provide support to large diverse populations, such as base operations support services, the contracting teams experienced a number of issues between the contractor, customer, and other organizations. The issues arose mostly due to a lack of training, standard processes and understanding of the contract footprint.

Lessons Learned. The lack of contract continuity was the biggest complaint from commanders, so the contracting teams began to establish CCAS Handbooks and External Customer Standard Operating Procedures to align and train all entities the contract touched. This was done to ensure that everyone from beginning to end understood the contracting processes. Within SOPs, a contracts roadmap would be highly effective; with so many contracts aligned side by side, leaders and entities needed to be able to clearly articulate any problems they were having by knowing whom to address and where one contract ended and the other began.

Expanding the Scope of Quality Assurance

Personnel charged with administering service contracts tend to heavily emphasize ensuring contractor compliance with the requirements of the PWS. In a contingency environment, there are additional risks that may not be readily apparent. The 926th QASs had to look beyond the PWS to ensure contractors complied with all contract requirements. The battalion expanded its QASPs to provide for systematic surveillance of contractor compliance with contract clauses related to CTIP, host nation labor laws, and sexual harassment and response prevention training. CTIP was a particularly pressing concern given some of the past issues related to pay, housing and working conditions for other-country nationals (OCNs) working for contractors in the U.S. Central Command Area of Responsibility. OCNs often comprise the majority of the contract labor pool in contingency areas and are vulnerable to abuse. The battalion's CTIP team conducted more than 150 audits to assess contractor compliance with contract CTIP requirements and host nation labor and housing laws.

Lesson Learned. Just like a military presence patrol in a counterinsurgency environment can serve as a deterrent to hostile forces while providing reassurance and security to the local populace, battalion CTIP audits deterred unethical contractor labor practices while providing contractor employees assurances of fair treatment. A well-written QASP will encompass systematic checks to ensure all requirements of the contract are adhered to by the contractor—not just the PWS.

Challenges

Training Shortages

During the deployment, the contract team ACOs and contract administrators experienced some training deficiencies. Because there are very few 1103-series civilian property administrators throughout ACC, the battalion experienced difficulties hiring for these positions during its deployment. Often lacking adequate property administrator support, ACOs were required to execute a number of detail- and time-intensive property management tasks. Counting on 1103 support, ACOs received minimal property training prior to deployment. This proved to be a major setback as ACOs struggled to understand these tasks and processes.

Additionally, within large contracts, the ACO takes on a large responsibility to ensure contractor purchase requests adhere to fiscal law rules, even though that area is not their specialty. With Army requirements, organization's lawyers review requests for government contract purchases to ensure fiscal law compliance. For contractor purchases, those same checks and balances are managed by the ACO. Contractor requests to purchase items directly linked to the contract requirement may not always comply fully with fiscal rules. ACOs need to be able to identify questionable purchase requests to seek clarification from acquisition lawyers.

Lesson Learned. With the property administrator shortages for the foreseeable future, 1102 and 51Cs should try to complete applicable Defense Acquisition University industrial property management courses. To strengthen fiscal law understanding, they should cross into the Army financial management courses, such as Comptroller Fiscal Law, provided by the Army Judge Advocate General School, or more advanced courses such as Planning, Programming, Budgeting, and Execution. Not only will property accountability and fiscal law training assist in post-award management, they also will significantly assist contracting officers and specialists during the pre-award phase.

Blurred Lines of Responsibility

On a number of occasions during the deployment, personnel from organizations outside the requiring activity (safety inspectors, environmental compliance officers, etc.) arrived unannounced at the contractor's on-post facilities to conduct inspections or surveys without the ACO's prior knowledge or approval. Since many of the contractor's facilities in a contingency environment are located on military installations and there is a sort of joint government-contractor occupation of the facilities, it can prove difficult to determine responsibility for oversight of support functions, such as safety or environmental compliance. External personnel visiting the area often do not understand that their presence can disrupt the contracting process, affect the contractor's performance, and even cause the government to incur unauthorized commitments.

Lesson Learned. Due to the specialized expertise of higher headquarters personnel, their support can help ensure contractor compliance with Army, local and host-nation laws and regulations. However, this engagement must occur within the framework of an established process: The personnel can be appointed as alternate CORs, which will give them the authority to conduct contractor surveillance in accordance with AR 70-13, *Management and Oversight of Services Acquisitions*. With establishment of an advance notification process, the ACO can review these visits properly and give contractor notification. The process should also require discussion of all findings with the ACO and quality assurance surveillance personnel who will make final decisions on changes required of the contractor to come into compliance.

Leveraging Lessons Learned and Challenges

Ultimately, soldiers serving on a CCAS mission return to their home stations with robust post-award contract administration experience. This affords them a unique understanding of what happens to a requirement after it is awarded. As the Army acquisition workforce continues to gain experience in post-award activities, it may ultimately overcome the "fire-and-forget" mentality that is a product of the disproportionate organizational emphasis on contracts awarded and dollars obligated. Greater emphasis on the post-award phase and the use of holistic contract administration will build an efficient and knowledgeable acquisition team that is able to reduce risks to soldiers, the mission and DoD funding.

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MDAP/MAIS Program Manager Changes

With the assistance of the Office of the Secretary of Defense, *Defense AT&L* magazine publishes the names of incoming and outgoing program managers for major defense acquisition programs (MDAPs) and major automated information system (MAIS) programs. This announcement lists all such changes of leadership, for both civilian and military program for May and June 2016, with an update for March.

Army

COL Charles Worshim relieved **COL Terrence Howard** for the Cruise Missile Defense Systems on June 15.

COL Troy Crosby relieved **COL Michael Thurston** for the Mission Command Program on June 15.

Navy/Marine Corps

CAPT Todd St. Laurent relieved **CAPT Leon R. Bacon** as program manager for the T-6B Joint Primary Aircraft Training System program (PMA 273) on March 4.

CAPT Kevin Smith relieved **CAPT James Downey** as program manager for Zumwalt Class Destroyer DDG-1000 (PMS 500) on May 23.

CAPT Keith Hash relieved **CAPT John Lemmon** as program manager for the E-2D Advanced Hawkeye Program (PMA 231) on May 26.

CAPT Anthony Rossi relieved **CAPT William Dillon** as program manager for the Multi-Mission Maritime Aircraft Program P-8A Poseidon (PMA 290) on May 30.

CAPT Kevin Byrne relieved **CAPT Theodore Zobel** as program manager for the Surface Ship Modernization (PMS 407) on June 21.

CAPT Theodore Zobel relieved **CAPT Casey Moton** as program manager for the Littoral Combat Ship Mission Modules (PMS 420) on June 21.

Air Force

Col. Brian Henson relieved **Col. Jeffrey Sobel** as program manager for the Advanced Medium-Range Air-to-Air Missile program in May 19.

Fourth Estate

None

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Defense AT&L

Writers' Guidelines in Brief

Purpose
Defense AT&L is a bimonthly magazine published by DAU Press, Defense Acquisition University, for senior military personnel, civilians, defense contractors and defense industry professionals in program management and the acquisition, technology and logistics workforce.

Submission Procedures
Submit articles by e-mail to datl@dau.mil. Submissions must include each author's name, mailing address, office phone number, e-mail address, and brief biographical statement. Each must also be accompanied by a copyright release. For each article submitted, please include three to four keywords that can be used to facilitate Web and data base searches.

Receipt of your submission will be acknowledged in 5 working days. You will be notified of our publication decision in 2 to 3 weeks. All decisions are final.

Deadlines
Note: If the magazine fills up before the author deadline, submissions are considered for the following issue.

Issue	Author Deadline
January–February	1 October
March–April	1 December
May–June	1 February
July–August	1 April
September–October	1 June
November–December	1 August

Audience
Defense AT&L readers are mainly acquisition professionals serving in career positions covered by the Defense Acquisition Workforce Improvement Act (DAWIA) or industry equivalent.

Style
Defense AT&L prints feature stories focusing on real people and events. The magazine seeks articles that reflect author experiences in and thoughts about acquisition rather than pages of researched information. Articles should discuss the individual's experience with problems and solutions in acquisition, contracting, logistics, or program management, or with emerging trends.

The magazine does not print academic papers; fact sheets; technical papers; white papers; or articles with footnotes, endnotes, or references. Manuscripts meeting any of those criteria are more suitable for DAU's journal, *Defense Acquisition Research Journal (ARJ)*.

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